R&S®ZNL
Noise Figure Measurements (SA Option R&S®FPL1-K30)
User Manual

1178649102
Version 12

ROHDE&SCHWARZ
Make ideas real

This manual applies to the following R&S®ZNL models with firmware version 1.71 and higher:

- R&S®ZNL3, 5 kHz to 3 GHz, 2 ports, N(f) connectors, order no. 1323.0012K03
- R&S®ZNL4, 5 kHz to 4.5 GHz, 2 ports, N(f) connectors, order no. 1323.0012K04
- R&S®ZNL6, 5 kHz to 6 GHz, 2 ports, N(f) connectors, order no. 1323.0012K06
- R&S®ZNL14, 5 kHz to 14 GHz, 2 ports, N(f) connectors, order no. 1323.0012K14
  Serial numbers 101200 and higher
- R&S®ZNL20, 5 kHz to 20 GHz, 2 ports, 3.5 mm (m) connectors, order no. 1323.0012K20
  Serial numbers 101200 and higher

The following firmware options are described:

- R&S®ZNL3-B1 Spectrum Analysis (1323.1802.02)
- R&S®ZNL4-B1 Spectrum Analysis (1303.8099.02)
- R&S®ZNL6-B1 Spectrum Analysis (1323.2067.02)
- R&S®ZNL14-B1 Spectrum Analysis (1303.8082.02)
- R&S®ZNL20-B1 Spectrum Analysis (1303.8101.02)
- R&S ZNL-K14 Independent CW Source (1303.8182.02)
- R&S FPL1-K30 Noise Measurements (1323.1760.02)

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Throughout this manual, products from Rohde & Schwarz are indicated without the ® symbol, e.g. R&S®ZNL is indicated as R&S ZNL.

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1 Preface

This chapter provides safety-related information, an overview of the user documentation and the conventions used in the documentation.

1.1 Documentation overview

This section provides an overview of the R&S ZNL user documentation. Unless specified otherwise, you find the documents at:

www.rohde-schwarz.com/manual/ZNL

www.rohde-schwarz.com/manual/ZNL or www.rohde-schwarz.com/manual/ZNLE.

1.1.1 Getting started manual

Introduces the R&S ZNL and describes how to set up and start working with the product. Includes basic operations, typical measurement examples, and general information, e.g. safety instructions, etc.

A printed version is delivered with the instrument. A PDF version is available for download on the Internet.

1.1.2 User manuals and help

Separate user manuals are provided for the base unit and the firmware applications:

- Base unit manual
  Contains the description of all instrument modes and functions. It also provides an introduction to remote control, a complete description of the remote control commands with programming examples, and information on maintenance, instrument interfaces and error messages. Includes the contents of the getting started manual.
- Firmware application manual
  Contains the description of the specific functions of a firmware application, including remote control commands. Basic information on operating the R&S ZNL is not included.

The contents of the user manuals are available as help in the R&S ZNL. The help offers quick, context-sensitive access to the complete information for the base unit and the firmware applications.

All user manuals are also available for download or for immediate display on the Internet.

1.1.3 Service manual

Describes the performance test for checking compliance with rated specifications, firmware update, troubleshooting, adjustments, installing options and maintenance.

The service manual is available for registered users on the global Rohde & Schwarz information system (GLORIS):

https://gloris.rohde-schwarz.com

1.1.4 Instrument security procedures

Deals with security issues when working with the R&S ZNL in secure areas. It is available for download on the Internet.

1.1.5 Printed safety instructions

Provides safety information in many languages. The printed document is delivered with the product.

1.1.6 Data sheets and brochures

The data sheet contains the technical specifications of the R&S ZNL. It also lists the firmware applications and their order numbers, and optional accessories.

The brochure provides an overview of the instrument and deals with the specific characteristics.

See www.rohde-schwarz.com/brochure-datasheet/ZNL

See www.rohde-schwarz.com/brochure-datasheet/ZNL or www.rohde-schwarz.com/brochure-datasheet/ZNLE.

1.1.7 Release notes and open source acknowledgment (OSA)

The release notes list new features, improvements and known issues of the current firmware version, and describe the firmware installation.

The software makes use of several valuable open source software packages. An open-source acknowledgment document provides verbatim license texts of the used open source software.

See www.rohde-schwarz.com/firmware/ZNL

See www.rohde-schwarz.com/firmware/ZNL or www.rohde-schwarz.com/firmware/ZNLE.

1.1.8 Application notes, application cards, white papers, etc.

These documents deal with special applications or background information on particular topics.

See www.rohde-schwarz.com/application/ZNL

See www.rohde-schwarz.com/application/ZNL or www.rohde-schwarz.com/application/ZNLE.

1.1.9 Calibration certificate

The document is available on https://gloris.rohde-schwarz.com/calcert. You need the device ID of your instrument, which you can find on a label on the rear panel.

1.2 Conventions used in the documentation

1.2.1 Typographical conventions

The following text markers are used throughout this documentation:

Convention	Description
"Graphical user interface elements"	All names of graphical user interface elements on the screen, such as dialog boxes, menus, options, buttons, and softkeys are enclosed by quotation marks.
[Keys]	Key and knob names are enclosed by square brackets.
`Filenames, commands, program code`	Filenames, commands, coding samples and screen output are distinguished by their font.
Input	Input to be entered by the user is displayed in italics.
Links	Links that you can click are displayed in blue font.
"References"	References to other parts of the documentation are enclosed by quotation marks.

1.2.2 Conventions for procedure descriptions

When operating the instrument, several alternative methods may be available to perform the same task. In this case, the procedure using the touchscreen is described. Any elements that can be activated by touching can also be clicked using an additionally connected mouse. The alternative procedure using the keys on the instrument or the on-screen keyboard is only described if it deviates from the standard operating procedures.

The term "select" may refer to any of the described methods, i.e. using a finger on the touchscreen, a mouse pointer in the display, or a key on the instrument or on a keyboard.

1.2.3 Notes on screenshots

When describing the functions of the product, we use sample screenshots. These screenshots are meant to illustrate as many as possible of the provided functions and possible interdependencies between parameters. The shown values may not represent realistic usage scenarios.

The screenshots usually show a fully equipped product, that is: with all options installed. Thus, some functions shown in the screenshots may not be available in your particular product configuration.

2 Welcome to the noise figure measurement application

The R&S FPL1-K30 is a firmware application that adds functionality to perform "noise figure" measurements to the R&S ZNL.

Availability of "Noise Figure" measurements

The "Noise Figure" measurements application becomes available when you equip the R&S ZNLxx with the optional spectrum analyzer hardware option R&S ZNLxx-B1 and firmware application R&S FPL1-K30.

For the R&S ZNLE and for R&S ZNL14 and R&S ZNL20 with serial numbers below 101200, these options are **not available**.

The Noise Source Control connector on the R&S ZNL is a prerequisite for the R&S FPL1 Noise Figure measurements application. This connector is part of the "Additional Interfaces" hardware option R&S FPL1-B5.

You must explicitly activate the use of this connector in the rear panel aux port configuration settings ([Setup] > "System Config" > "Add. Interfaces" > "SA (Aux 5V)"). Make sure a compatible device is connected to the interface before you activate it, to avoid damage to the connected device.

See the R&S ZNL User Manual, "General Instrument Setup".

If the Noise Source Control connector is not enabled, a warning is displayed in the R&S FPL1 Noise Figure measurements application status bar indicating that the noise source control is disabled.

This user manual contains a description of the functionality that the application provides, including remote control operation.

Functions that are not discussed in this manual are the same as in the Spectrum application and are described in the R&S ZNL user manual.

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2.1 Starting the noise application

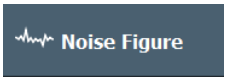
The "noise figure" measurement application adds a new type of measurement to the R&S ZNL.

To activate the R&S FPL1 Noise Figure measurements application

1. Select the [MODE] key.

   A dialog box opens that contains all operating modes and applications currently available on your R&S ZNL.

2. Select the "Noise Figure" item.



The R&S ZNL opens a new measurement channel for the "noise figure" measurement application.
All settings specific to "noise figure" measurements are in their default state.

Multiple Channel Setups and Sequencer Function

When you activate an application, a new channel setup is created which determines the measurement settings for that application ("Channel"). The same application can be activated with different measurement settings by creating several "Channel"s for the same application.

The number of channel setups that can be configured at the same time depends on the available memory on the instrument.

Only one measurement can be performed at any time, namely the one in the currently active channel setup. However, to perform the configured measurements consecutively, a Sequencer function is provided.

If activated, the measurements configured in the currently defined "Channel"s are performed one after the other in the order of the tabs. The currently active measurement is indicated by a ⚙ symbol in the tab label.

The result displays of the individual channel setups are updated in the tabs (as well as the "MultiView") as the measurements are performed. Sequential operation itself is independent of the currently *displayed* tab.

For details on the Sequencer function, see the R&S ZNL user manual.

2.2 Understanding the display information

The following figure shows the display as it looks for "noise figure" measurements. All different information areas are labeled. They are explained in more detail in the following sections.

Figure 2-1: Screen layout of the noise figure measurement application

1 = Toolbar
2 = Channel Setup bar
3 = Diagram header
4 = Result display
5 = Softkey bar
6 = Status bar

Channel Setup bar information

In the R&S FPL1 Noise Figure measurements application, the R&S ZNL shows the following settings:

Ref Level	Reference level of the R&S ZNL.
Att	Attenuation of the R&S ZNL.
RBW	Resolution bandwidth
SWT	Sweep time
AVG	Number of averages
ENR	Excess noise ratio For smart noise sources: also the provided temperature
2nd Stage Corr	State of the 2nd stage correction.
Calibration Data	Date and time of the current calibration data.
Mode	Currently selected measurement mode.

Window title bar information

For each diagram, the header provides the following information:

Figure 2-2: Window title bar information for the R&S FPL1 Noise Figure measurements application

1 = Window number
2 = Window type
3 = Trace color and number
4 = Trace mode

Status bar information

Global instrument settings, the instrument status and any irregularities are indicated in the status bar beneath the diagram. Furthermore, the progress of the current operation is displayed in the status bar.

NOTICE

Risk of damaging the instrument

Make sure not to overload the input mixer during calibration and the measurement. An overload condition can damage or destroy the input mixer.

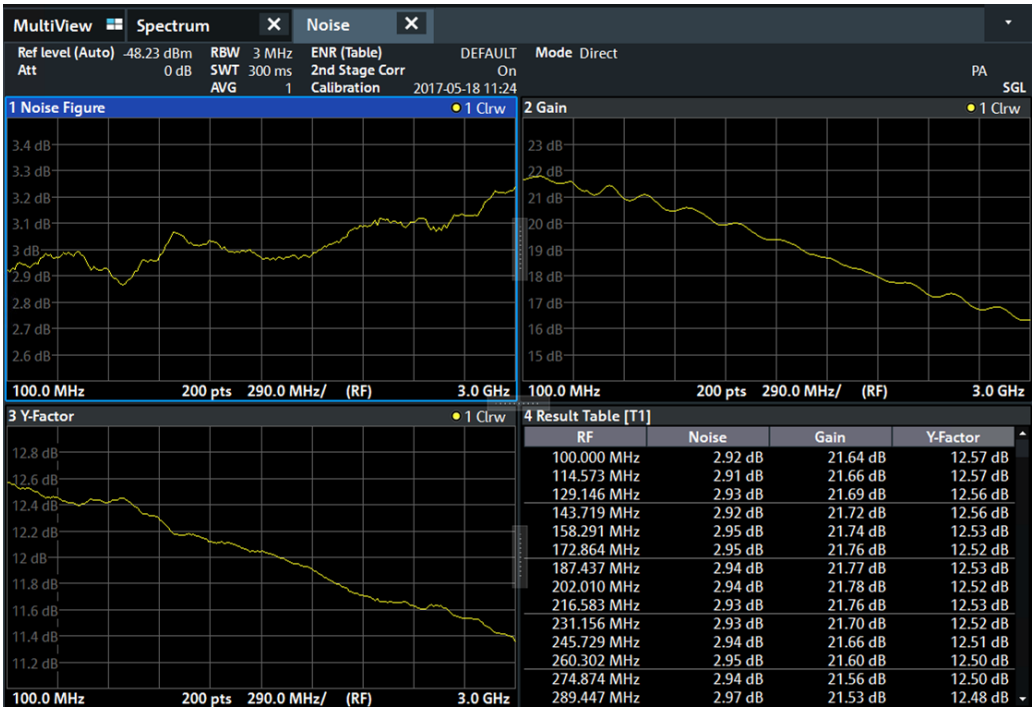
If an overload condition occurs, the R&S ZNL shows a corresponding message in the status line ("RF OVLD" or "IF OVLD").

To avoid an overload during calibration or measurement, do one or more of the following:

- Check and adjust the DUT "gain" settings
- Check and adjust the ENR settings
- Increase the reference level.

3 Measurements and result displays

The R&S FPL1-K30 measures the "noise figure" of a DUT and displays the results graphically and numerically. Each graphical result display shows the "noise figure" from a different perspective. In the default configuration, the application shows the "noise figure" of the DUT, the "gain" of the DUT and the corresponding "y-factor". In addition, it shows the numerical results of the measurement.



The scale of the horizontal axis depends on the tuning mode.

Frequency list and swept measurements

In all graphical result displays, the horizontal axis represents the frequency. The displayed frequency is either the RF (radio frequency) or the IF (intermediate frequency). The range depends on the frequency set you have currently defined. Because the application only measures selected frequencies, it connects the results to draw a trace.

Negative "noise figure" and "noise temperature"

From a physical point of view, the "noise figure" and the "noise temperature" levels have a positive range (including zero).

Due to the mathematical operations the application performs, the results can be negative. Sometimes this happens due to incorrect calibration or variance of measurement values.

Single frequency measurements

In all graphical result displays, the horizontal axis represents a chronological order of measurement results for the frequency you are testing. The axis has no unit, but is made up out of several index values that represent time. Each index value represents one measurement point and therefore one measurement on the single frequency you are analyzing. The size of the index (and thus number of results) depends on the number of (Measurement) Points that you have defined. Because the application only measures at certain points in time, it connects the results to draw a trace.

The right diagram border represents the present (index = 0), values to the left represent past measurement results (index = -<x>). As soon as the application finishes a single measurement, the measurement points are moved to the left, the new result is added on the right. All other measurement points are moved down one position with the most obsolete result falling out of the diagram (like in the roll mode of an oscilloscope).

Selecting the result display

► Select the icon in the toolbar or press the [MEAS] key.

The application enters the SmartGrid configuration mode.

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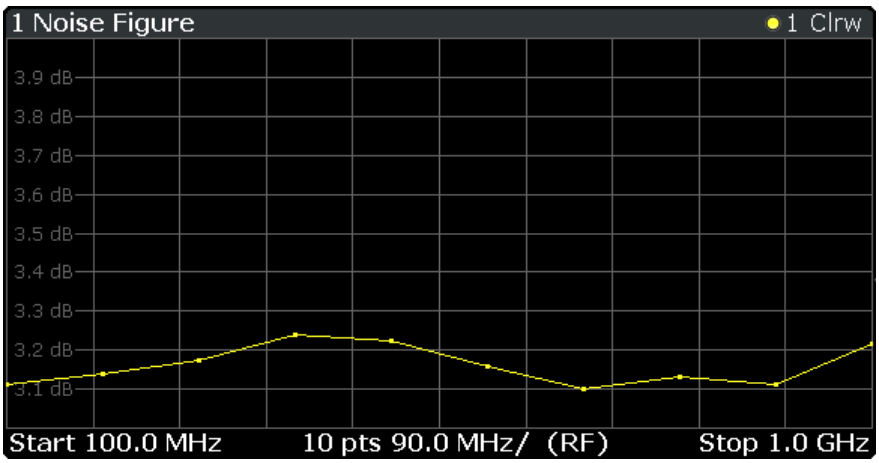
Noise Figure

Shows the "noise figure" of the DUT.

The "noise figure" is the ratio of the signal-to-noise ratio at the DUT input to the signal-to-noise ratio at the DUT output.

$$\text{Noise Figure} = \frac{SNR_{in}}{SNR_{out}}$$

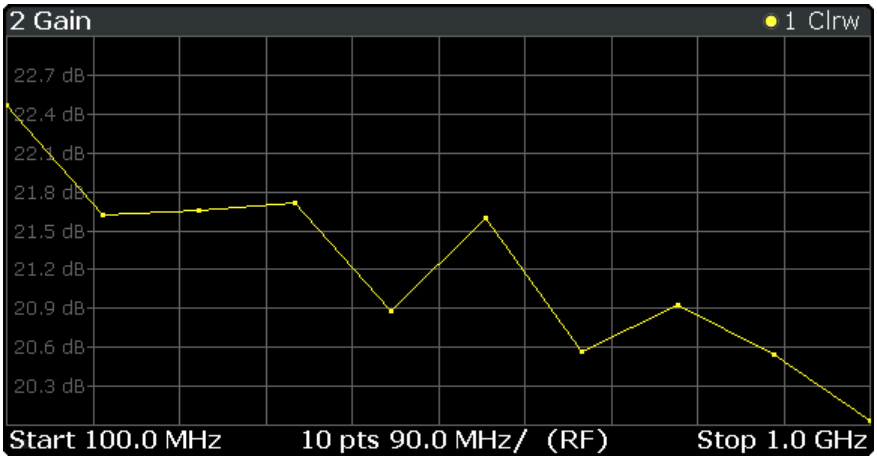
The vertical axis shows the level of the "noise figure" in dB. The scale depends on the settings in the "Display Configuration" dialog box.



Remote command:
`LAY:ADD:WIND? '2',RIGH,NOIS` see `LAYout:ADD[:WINDow]?` on page 98
Results:`TRACe<t>[:DATA]? <Trace>,NOISe`

Gain
Shows the "gain" characteristics of the DUT.

The vertical axis shows the level of the "gain" in dB. The scale depends on the settings in the "Display Configuration" dialog box.



Remote command:
`LAY:ADD:WIND? '2',RIGH,GAIN` see `LAYout:ADD[:WINDow]?` on page 98
Results:`TRACe<t>[:DATA]? <Trace>,GAIN`

Noise Temperature
Shows the "noise temperature" characteristics of the DUT.

$$\text{Noise Temperature} = \frac{P}{B \cdot k}$$

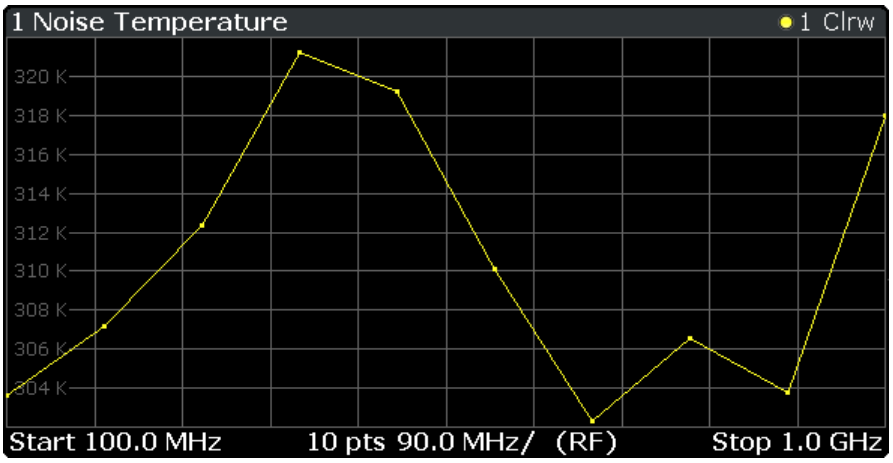
with

P = Power

B = Bandwidth

k = Boltzmann constant

The vertical axis shows the "noise temperature" in Kelvin. The scale depends on the settings in the "Display Configuration" dialog box.



Remote command:

`LAY:ADD:WIND? '2',RIGH,TEMP` see `LAYout:ADD[:WINDow]?` on page 98

Results: `TRACe<t>[:DATA]? <Trace>,TEMPerature`

Y-Factor

Shows the ratio of the hot and the cold power of the DUT.

The "Y-factor" indicates the quality of measurement tolerances and uncertainties. To get the result, the application measures the DUT power with the noise source turned on (hot power) and the noise source turned off (cold power).

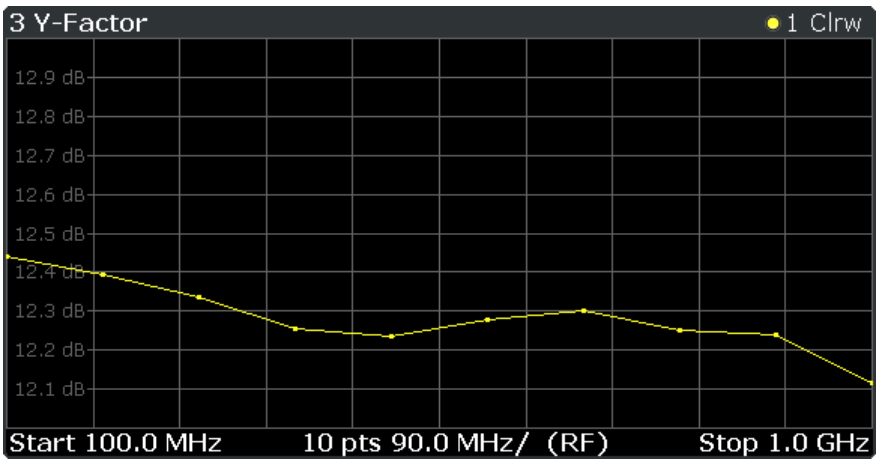
$$\text{Y-Factor} = \frac{N_{on}}{N_{off}}$$

with

N_{on} = Noise power [dB] with noise source on

N_{off} = Noise power [dB] with noise source off

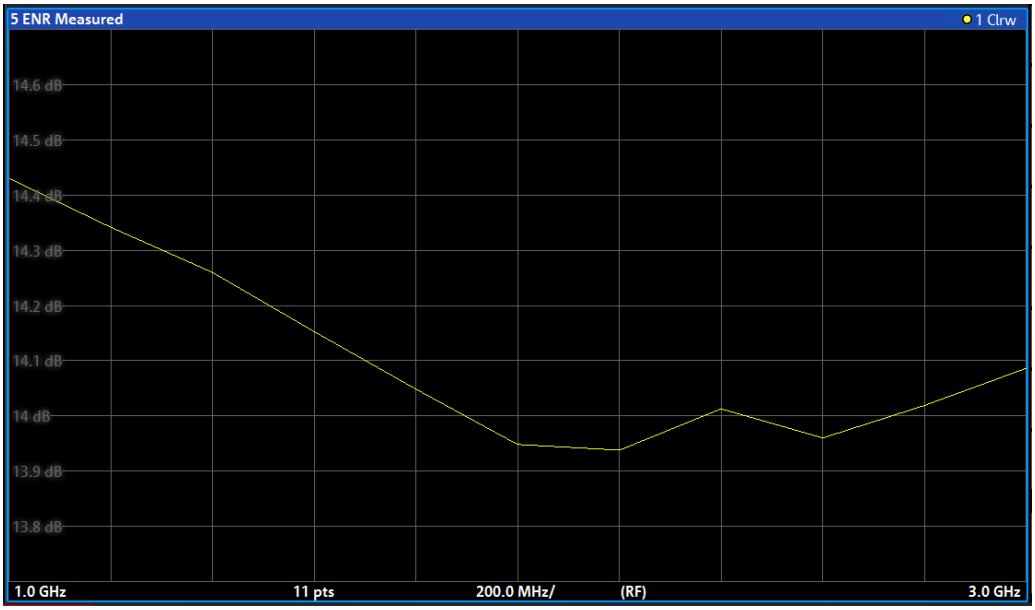
The vertical axis shows the linear relation. The scale depends on the settings in the "Display Configuration" dialog box.



Remote command:
`LAY:ADD:WIND? '2',RIGH,YFAC` see `LAYout:ADD[:WINDow]?` on page 98
Results: `TRACe<t>[:DATA]? <Trace>,YFACtor`

ENR Measured
Shows the results of the ENR measurement.

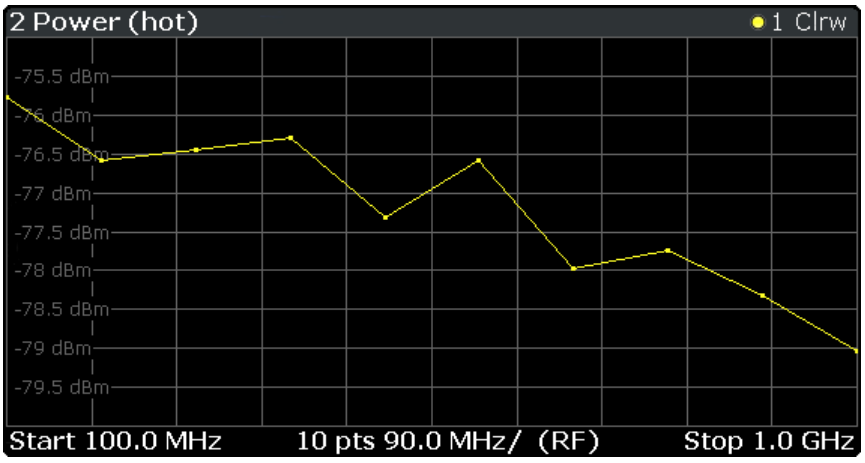
To measure the ENR of a noise source, first attach a noise source with known ENR to the device, enter the ENR of this noise source to the calibration ENR table and calibrate using this one. Then, attach the unknown noise source to the device and perform a measurement ("Run Single") with this one. The graph shown in the ENR Measured display and the results for ENR Measured in the Result Summary will be the ENR of the noise source at the measured frequencies. The vertical axis shows the level of the measured ENR in dB. The scale depends on the settings in the "Display Configuration" dialog box.



Remote command:
LAY:ADD:WIND? '2',RIGH,ENR see LAYout:ADD[:WINDow]? on page 98
Results: TRACe<t>[:DATA]? <Trace>,ENR

Power (Hot)
Shows the absolute power characteristics at the instrument input. The noise source is turned on.

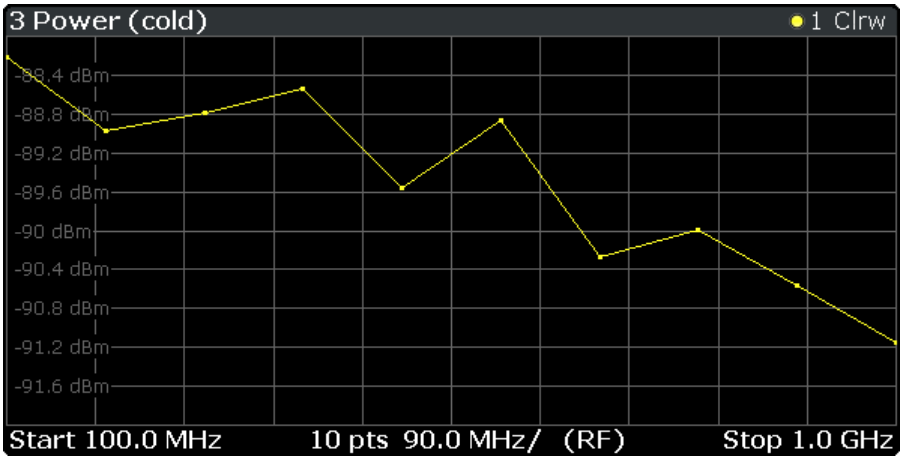
The vertical axis shows the power in dBm. The scale depends on the settings in the "Display Configuration" dialog box.



Remote command:
LAY:ADD:WIND? '2',RIGH,PHOT see LAYout:ADD[:WINDow]? on page 98
Results: TRACe<t>[:DATA]? <Trace>,PHOT

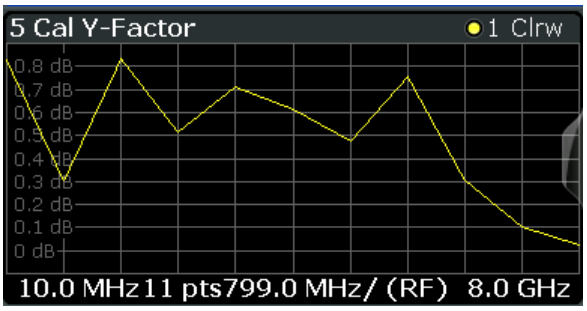
Power (Cold)
Shows the absolute power characteristics at the instrument input. The noise source is turned off.

The vertical axis shows the power in dBm. The scale depends on the settings in the "Display Configuration" dialog box.



Remote command:
LAY:ADD:WIND? '2',RIGH,PCOL see LAYout:ADD[:WINDow]? on page 98
Results: TRACe<t>[:DATA]? <Trace>,PCOLd

Cal Y-Factor
Shows the ratio of the hot and the cold power measured during calibration.



The "Y-factor" indicates the quality of measurement tolerances and uncertainties. To get the result, the application measures the power with the noise source turned on (hot power) and the noise source turned off (cold power), but without the DUT inserted.

$$\text{Y}-\text{Factor} = \frac{N_{on}}{N_{off}}$$

with

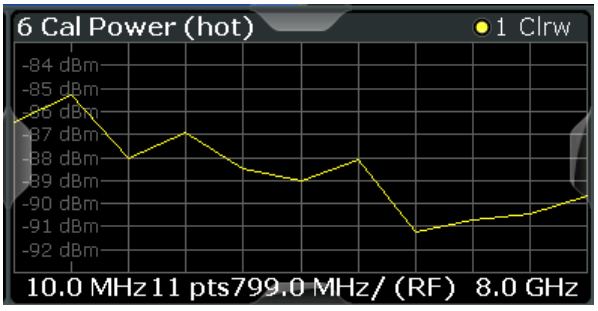
N_{on} = Noise power [dB] with noise source on

N_{off} = Noise power [dB] with noise source off

The vertical axis shows the linear relation. The scale depends on the settings in the "Display Configuration" dialog box.

Remote command:
LAY:ADD:WIND? '2',RIGH,CYF see LAYout:ADD[:WINDow]? on page 98
Results: TRACe<t>[:DATA]? <Trace>,CYFactor

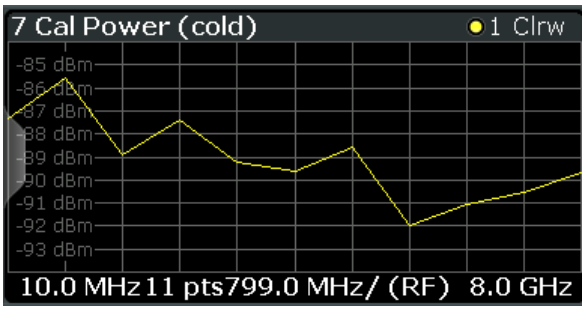
Cal Power (Hot)
Shows the absolute power characteristics at the instrument input during the calibration measurement. The noise source is turned on, the DUT is not inserted.



The vertical axis shows the power in dBm. The scale depends on the settings in the "Display Configuration" dialog box.

Remote command:
LAY:ADD:WIND? '2',RIGH,CPH see LAYout:ADD[:WINDow]? on page 98
Results: TRACe<t>[:DATA]? <Trace>,CPHot

Cal Power (Cold)
Shows the absolute power characteristics at the instrument input during the calibration measurement. The noise source is turned off, the DUT is not inserted.



The vertical axis shows the power in dBm. The scale depends on the settings in the "Display Configuration" dialog box.

Remote command:
LAY:ADD:WIND? '2',RIGH,CPC see LAYout:ADD[:WINDow]? on page 98
Results: TRACe<t>[:DATA]? <Trace>,CPCold

Result Table
Shows the measurement results in numerical form in a table.

The contents of the table depend on the "Display Settings". By default it shows the "noise figure", "gain" and "y-factor" results. Each row represents one measurement point. Each column represents one result type. The first column shows the measurement frequency.

The result table shows either the RF or the IF, depending on your selection.

For more information, see Chapter 6.1.2, "Configuring numerical results", on page 79.

4 Result Table [T1]

RF	Noise	Gain	Y-Factor	ENR
1.000 GHz	0.02 dB	-0.02 dB	10.18 dB	14.43 dB
1.200 GHz	-0.00 dB	-0.01 dB	9.96 dB	14.34 dB
1.400 GHz	-0.03 dB	0.01 dB	9.67 dB	14.26 dB
1.600 GHz	0.00 dB	0.01 dB	9.38 dB	14.15 dB
1.800 GHz	-0.10 dB	-0.03 dB	9.31 dB	14.05 dB
2.000 GHz	-0.02 dB	0.01 dB	9.03 dB	13.95 dB
2.200 GHz	0.11 dB	0.01 dB	8.93 dB	13.94 dB
2.400 GHz	-0.03 dB	0.03 dB	8.83 dB	14.01 dB
2.600 GHz	0.11 dB	-0.02 dB	8.67 dB	13.96 dB
2.800 GHz	0.02 dB	-0.00 dB	8.61 dB	14.02 dB
3.000 GHz	-0.08 dB	0.02 dB	8.44 dB	14.09 dB

Remote command:
LAY:ADD:WIND? '2',RIGH,RES see LAYout:ADD[:WINDow]? on page 98
Results: TRACe<n>[:DATA]? on page 105
Table items: DISPlay[:WINDow<n>]:TABLe:ITEM on page 148

Current Values
Shows the result at the current measurement point.

The contents of the "Current" result display are updated as soon as a new measurement point is analyzed.

The result types shown in the table depend on the "Display Settings". By default it shows the results for the "Noise Figure", "Gain" and "Y-Factor" result type. Each row represents one result type. The first column shows the result type, the second column shows the result.

For more information, see Chapter 6.1.2, "Configuring numerical results", on page 79.

Marker Table
Shows the marker characteristics in numerical form in a table.

The size of the table depends on the number of active markers and the way you have configured the table in the "Result Config" dialog box. For more information, see Chapter 6.3, "Using markers", on page 83 and Chapter 6.1.2, "Configuring numerical results", on page 79.

4 Marker Table

Type	Ref	Trc	Stimulus	Noise	Gain
N1		1	400.00 MHz	3.24 dB	21.72 dB
D2	N1	1	100.00 MHz	-0.01 dB	-0.84 dB
D3	N1	1	200.00 MHz	-0.08 dB	-0.12 dB

The first four columns of the table are fix.

- Type
  Shows the marker type. 'M' represents a normal marker, 'D' represents a delta marker.
- Ref
  Shows the reference marker for relative delta markers.
- Trc
  Shows the trace that the marker is positioned on.
- X-value
  Shows the horizontal position (frequency) of the marker.
  For normal markers, the position is an absolute value. The position of delta markers is relative to another marker.
- <Result>
  Shows the measurement result at the marker position.
  For normal markers, the result is an absolute value. Results for delta markers are relative to another marker.

Remote command:
`LAY:ADD:WIND? '2',RIGH,MTAB` see `LAYout:ADD[:WINDow]?` on page 98
Results:
`CALCulate<n>:MARKer<m>:Y?` on page 167
`CALCulate<n>:DELTamarker<m>:Y?` on page 170

4 Measurement basics

The measurement basics contain background information on the terminology and principles of "noise figure" measurements.

"Noise figure" measurements determine the noise that a device under test (DUT) adds to a signal as that signal passes through the DUT.

- Tuning modes 24
- Measurement modes 27
- DUT types 29
- Image frequency rejection 30
- Calibration (2nd stage correction) 32
- Using smart noise sources 36
- Separating signals by selecting an appropriate resolution bandwidth 36
- Analyzing several traces - trace mode 37
- Using markers 38

4.1 Tuning modes

Basically, the application calculates the "noise figure" of a DUT based on the characteristics of the DUT that have been measured and a noise source whose properties are known. Therefore, the Noise Source Control connector on the R&S ZNL is a prerequisite for the R&S FPL1 Noise Figure measurements application.

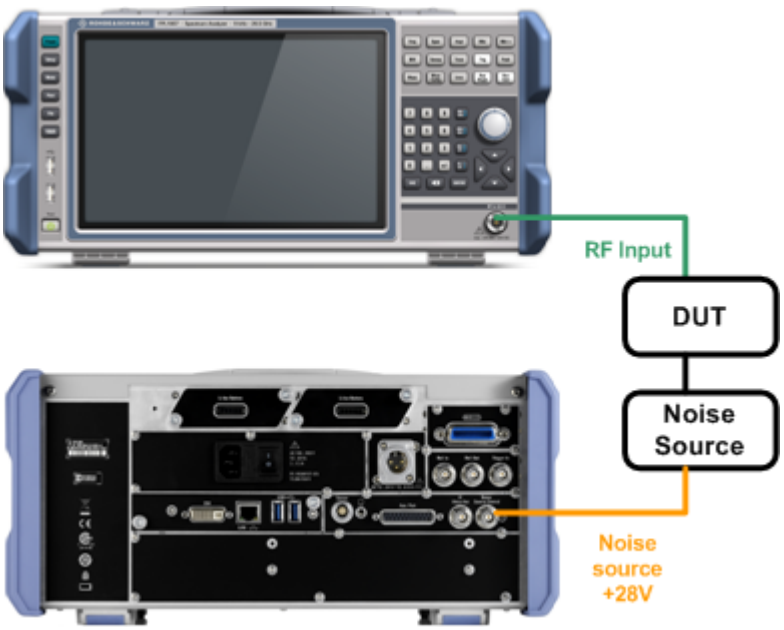
Noise Source Control

You must explicitly activate the use of this connector in the rear panel aux port configuration settings ([Setup] > "System Config" > "Add. Interfaces" > "SA (Aux 5V)"). Make sure a compatible device is connected to the interface before you activate it, to avoid damage to the connected device.

See the R&S ZNL User Manual, "General Instrument Setup".

If the Noise Source Control connector is not enabled, a warning is displayed in the R&S FPL1 Noise Figure measurements application status bar indicating that the noise source control is disabled.

In addition to the noise characteristics of a DUT, the application is also able to determine several more DUT characteristics like its "gain" or its "noise temperature" characteristics.



The application provides several measurement modes or **tuning modes**.

- Swept measurements 25
- Frequency table measurements 26
- Single frequency measurements 26

4.1.1 Swept measurements

The **sweep** tuning mode performs measurements on a set of discrete frequencies based on the frequency parameters. Each measurement analyzes the noise characteristics of the corresponding frequency or measurement point.

For swept measurements, the application automatically determines the measurement frequencies and combines them in a frequency list.

Such a frequency set is the result of the frequency and span information that you have provided. The frequency and span information is made up out of the center frequency, the span, the start and the stop frequency. In combination with the measurement points or the frequency table step size, the application calculates the contents of the frequency table.

The **center frequency** is the frequency in the center of the frequency band you are measuring. Thus, it is defined either by the span, or the start and stop frequencies.

The **measurement points** is the number of entries in a frequency list and thus the number of measurements that the application performs during a "noise figure" measurement.

The **stepsize** defines the distance between two measurement points. It is constant for all measurement points.

If the stepsize is larger than the distance between start and stop frequency, the frequency table consists of the start and stop frequencies only.

4.1.2 Frequency table measurements

The **frequency table** tuning mode also performs measurements on a set of frequencies based on the contents of a frequency list. Each measurement analyzes the noise characteristics of the corresponding frequency.

Compared to a swept measurement, you can customize the contents of the frequency list. Thus, you can add frequencies that are independent of the frequency stepsize and the number of measurement points.

Frequency tables also allow you to define a variable RBW and sweep time, depending on the current frequency of the sweep point (see "Variable RBW and sweep time for low-frequency measurements" on page 37 and Chapter 5.2.3, "Using a frequency table", on page 47).

4.1.3 Single frequency measurements

The **single frequency** tuning mode performs one or several consecutive measurements on a single frequency. You can perform the measurement on any frequency that is supported by the hardware you are using.

Single frequency measurements are a way to facilitate manual adjustments for "noise figure" measurements. They also allow you to get an idea about how the "noise figure" at a particular frequency change over time.

Note that sweep lists or frequency tables are not considered in this measurement mode.

Single frequency measurement results

For single frequency measurements, the same set of graphical result displays is available as for frequency list measurements ("Noise Figure", "Gain" etc.). Note, however, that the x-axis has no unit, but shows a series of results taken for a single frequency. The number of displayed results depends on the number of measurement points you have defined.

For more information, see Chapter 3, "Measurements and result displays", on page 15.

In addition, you can also view the results in the Result Table in numerical form.

Single frequency measurements are not available when you are using a resistor as a noise source.

4.2 Measurement modes

In some cases, the Power (Hot) and Power (Cold) results require two different noise sources with different temperature characteristics (cold and hot). Measurements with a resistor noise source are such a case.

Usually, noise sources with diode characteristics are used for "Noise Figure" measurements. These noise sources have two states, on and off. When they are supplied with power (state = on), the application measures the hot power, when they are not supplied with power (state = off), it measures the cold power. Turning the noise source on and off is automatically done by the application, so that you can get the hot and cold power characteristics in a single step.

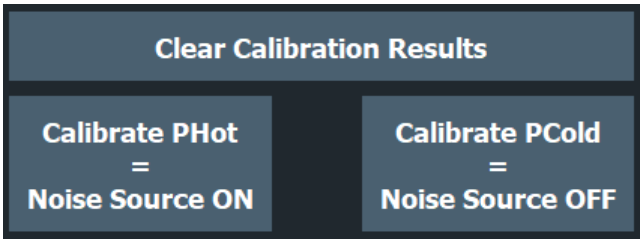
This **automatic measurement mode** is the default measurement mode of the R&S FPL1 Noise Figure measurements application.

A resistor noise source, however, requires two resistors, one hot and one cold. You have to substitute the hot resistor by the cold resistor to measure first the hot and then the cold power. For these cases, the application provides a **manual measurement mode**. This measurement mode is automatically selected when you select a "Noise Source" on page 53 with resistor characteristics, but is not restricted to those cases.

The manual measurement mode is available for measurements and the calibration stage.

Performing a manual measurement

In manual measurement mode, you have to measure (or calibrate) the hot and cold power characteristics of the DUT separately. When you start the measurement, the application opens a dialog box that allows you to select the type of measurement to perform next.

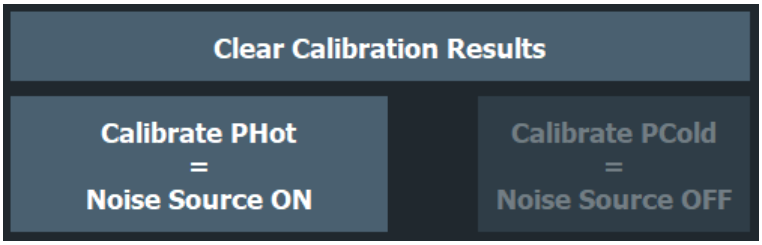


Recommended order of measurements

Note that it is recommended that you begin with the hot power measurement.

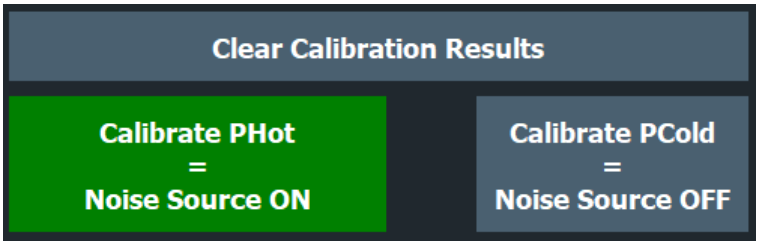
Furthermore, calibration always begins with the hot power measurement.

In case the hot power has to be measured first, the cold power measurement is unavailable:

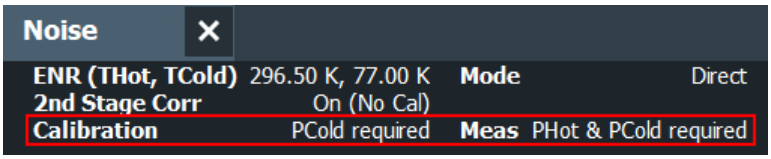


When the first measurement is done, you can change the test setup by connecting the other resistor. Then start the second measurement.

In the dialog box, the measurement stage that is already done is labeled green.



In addition, the application shows the missing calibration and measurement steps in the channel bar.



Clearing results

To replace the previous calibration or measurement results, clear the currently stored data using the "Clear Calibration Results" or "Clear Measurement Results" function.

Returning to automatic measurement mode

When you are in automatic measurement mode and select a noise source with resistor characteristics, the application automatically selects the manual measurement mode.

When you are in manual measurement mode and select a noise source with diode characteristics, you have to select the automatic measurement mode deliberately in the "Sweep" menu.

4.3 DUT types

"Noise figure" measurements are possible on DUTs with a wide variety of characteristics. The DUT characteristics not only affect the test setup, but also determine the way the application populates the frequency list for swept measurements.

The R&S FPL1 Noise Figure measurements application supports measurements on DUTs that work on a fixed frequency as well as measurements on frequency-converting DUTs.

- Measurements on linear DUTs (direct measurement).....29
- Measurements on frequency converting DUTs.....29

4.3.1 Measurements on linear DUTs (direct measurement)

For a linear DUT, the RF frequency remains the same between its input and output. For measurements on such DUTs, it is sufficient to measure the signal's RF frequency without any additional equipment (like a local oscillator). A typical linear DUT is an amplifier, for example.

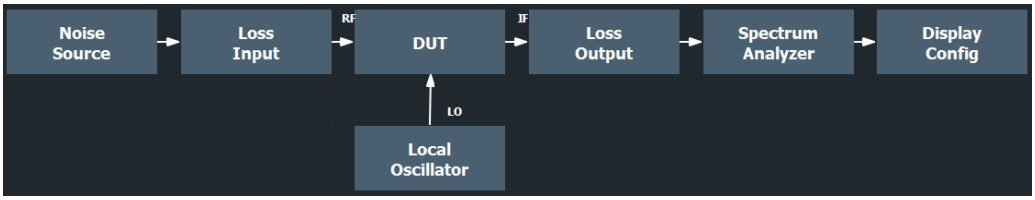
The test setup for measurements on such DUTs usually consists of the noise source, the DUT and an analyzer. If necessary, the measurement also considers loss that occurs somewhere in the measurement path.

For linear DUTs, the contents and layout of the "Overview" dialog box represents the configuration of a typical test setup.

4.3.2 Measurements on frequency converting DUTs

A frequency converting DUT converts the RF frequency to an intermediate frequency (IF) using the local oscillator (LO). A frequency-converting DUT either converts the RF frequency to a lower IF (down-conversion) or a higher IF (up-conversion).

If you have selected a frequency-converting DUT measurement mode, the layout of the "Overview" dialog box adds the local oscillator to the test setup.



The local oscillator can have a fixed or a variable frequency. If the LO frequency is fixed, the intermediate frequency (IF) resulting from the conversion process is variable (depending on the input signal). If the LO frequency is variable, the IF has to be fixed.

The R&S FPL1 Noise Figure measurements application supports only the fixed LO frequency measurement method.

Fixed LO frequency

If you select one of the fixed LO measurement modes, the LO frequency is the same for all entries in the frequency list. The IF frequency for each entry is variable and is the result of the equation the selected mode is based on.

- $f_{RF} + f_{LO}$ for up-converters
- $f_{RF} - f_{LO}$ for down-converters

The fixed LO measurement modes are, for example, required for measurements on satellite converters.

4.4 Image frequency rejection

Frequency converting DUTs convert a radio frequency (RF) to an intermediate frequency (IF). The IF is lower than the RF for down-converting DUTs, and higher than the RF for up-converting DUTs.

In a basic test setup, the image frequency of the RF signal is also converted to the IF. Depending on the DUT, this effect can be wanted or even necessary, or not. To avoid measurement errors of the "noise figure" and "gain" of up to 3 dB, make sure to use the appropriate measurement configuration.

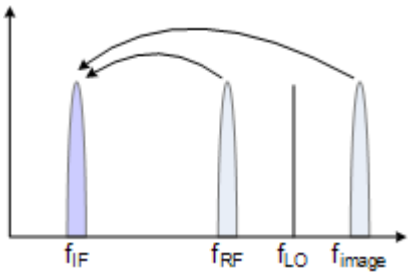
Basically, you can distinguish between single sideband (SSB) mixers, double sideband (DSB) mixers, and mixers that partly suppress a sideband. If a sideband is not needed or only partly needed, you can reject the image frequency. If you do so, the application activates a filter that suppresses the image frequency to a certain extent.

The following illustrations help you configure the measurement correctly.

For more information on how to configure image rejection, see "Image Rejection" on page 50.

Double sideband measurements

Double sideband mixers use both sidebands to the same extent. Both RF and image frequency are converted. In that case, turn off image rejection.

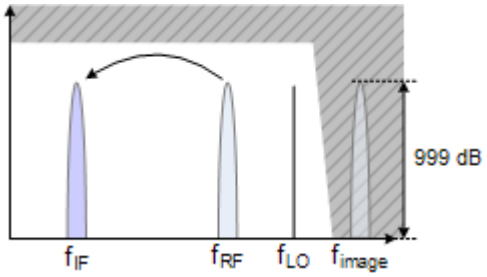


f_{LO} = frequency of the local oscillator
f_{IF} = intermediate frequency = $f_{RF} \pm f_{LO}$
f_{RF} = lower sideband = $f_{LO} - f_{IF}$
f_{image} = upper sideband = $f_{LO} + f_{IF}$

If image rejection is on, the results have a 3 dB error. That means "noise figure" results are 3 dB lower than they should be. "Gain" results are 3 dB higher.

Single sideband measurements

Single sideband mixers use a single sideband only. In that case, you have to suppress the sideband that is not required. If you do so, the measurement is like on an amplifier.

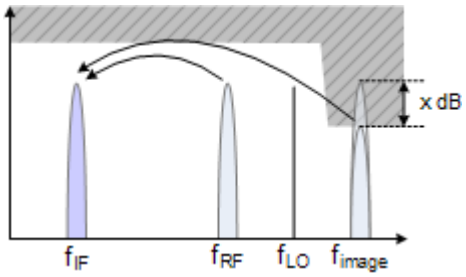


To suppress a sideband completely, it is best to set the image rejection to the maximum amount possible (999.99 dB).

Partial sideband suppression

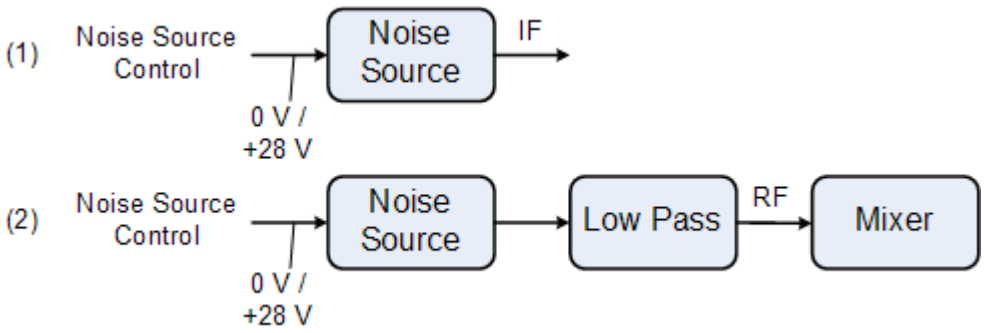
For measurements on mixers with a low image frequency rejection, there are two test scenarios.

- Mixers whose image rejection is known.
- Mixers whose image rejection is unknown.



For mixers whose image rejection is known, define the magnitude of image rejection in dB as accurately as possible. Otherwise, measurement results ("noise figure" and "gain") deviate between 0 dB to 3 dB.

If you do not know the image rejection characteristics of a mixer, use a custom test setup including an additional filter. You also have to know the "gain" characteristics of the DUT.



(1) = Test setup for calibration
(2) = Test setup for "noise figure" measurement

In the test setup shown above, a lowpass filter prevents unwanted noise from being fed in at the image frequency.

Depending on the position of the frequency bands, you might need a highpass or bandpass filter for the RF frequency instead of the lowpass filter. The important point is that unwanted noise is not converted by a further receive path of the mixer. The unwanted noise at the receive frequency must not be reduced. The insertion loss must be considered, if applicable.

With this test setup, the measurement on a mixer without sideband suppression is the same as SSB measurements.

To take the characteristics of the filter into account, include the insertion loss of the filter at the RF. To consider the actual filter suppression at the image frequency, include the actual attenuation for the image rejection.

Harmonics mixer measurement

For a harmonics mixer, the input signals are not only converted to the IF by the wanted harmonic. The harmonic of the LO signal produced in the mixer is also converted. Often, the mixer even features a lower conversion loss for unwanted harmonics. For measurements on this type of mixer, you have to use a bandpass filter. The filter ensures that there is only noise at the desired frequency at the input of the DUT. This measurement is similar to measurements on a mixer with an average sideband suppression.

4.5 Calibration (2nd stage correction)

The calibration procedure of the application measures the inherent noise of the R&S ZNL you are using. Performing calibration is therefore recommended, as it increases the accuracy of measurement results. The results get more accurate because the application takes the inherent noise of the analyzer into account while it calculates the results.

Calibration for "noise figure" measurements is also known as 2nd stage correction. This term is used because in a typical "noise figure" test setup, the DUT represents the first stage and the analyzer the second stage in the test setup.

The 2nd stage correction is a calibration that is specific to "noise figure" measurements. It is independent of the overall calibration state of the analyzer and does not calibrate the analyzer.

For successful calibration, you need additional equipment.

- Noise source
  The noise source is like a calibration standard. It provides a reference with known noise characteristics that allows the application to determine the inherent noise of the analyzer you are using.

During the calibration, the application measures the inherent noise characteristics of the analyzer at the set of measurement frequencies.

Thus, the 2nd stage correction is valid for a particular instrument configuration, the room temperature and the instrument temperature. As long as this configuration stays the same, calibration data remains valid.

Calibrating single frequency measurements

Like for all other measurements of the R&S FPL1 Noise Figure measurements application, perform a calibration before a single frequency measurement for increased accuracy.

There is an easy way to calibrate single frequency measurements, if you already calibrated the application for swept or list measurements. If the single frequency is part of the frequency list, the measurement is already calibrated for that frequency and no further steps are necessary. The application recalls the last calibration values when you switch back to sweep mode or frequency table mode.

Only if you use a single frequency that is not part of the frequency list, you must calibrate this frequency point first.

- Interpolation
  If you change the frequency, while the frequency span stays the same or is reduced, the application interpolates the correction data for the new measurement points. A new calibration is not required.
  However, measurements based on interpolated data can result in an increased measurement uncertainty. Highly accurate measurements that are conform to the values specified in the data sheet are only possible at calibrated measurement points.
  Note that useful interpolation is possible only if essential calibration parameters (e.g. impedance or attenuation) change only slightly. This is the case if the distance between the original calibration points is sufficiently small.
  If the span increases compared to the span during calibration, a new calibration is necessary.
  If the application interpolates the calibration data, it shows a corresponding label in the channel bar and a warning message in the status bar.
- Invalid calibration
  If you change one of the amplitude parameters (e.g. the attenuation), calibration is labeled invalid. In that case, calibration is not accurate, because the settings are not in line with the settings at the time the R&S ZNL has been calibrated. If calibra-

tion is invalid, repeat the calibration or restore the settings as they were during the calibration.

Saving calibration data

If you save the current configuration or measurement results to a data set, calibration data is part of that data set.

For more information on saving and restoring data sets, see the "Storing and Recalling Instrument Settings and Measurement Data" chapter in the R&S ZNL user manual.

The picture below shows a typical calibration setup that includes a noise source.

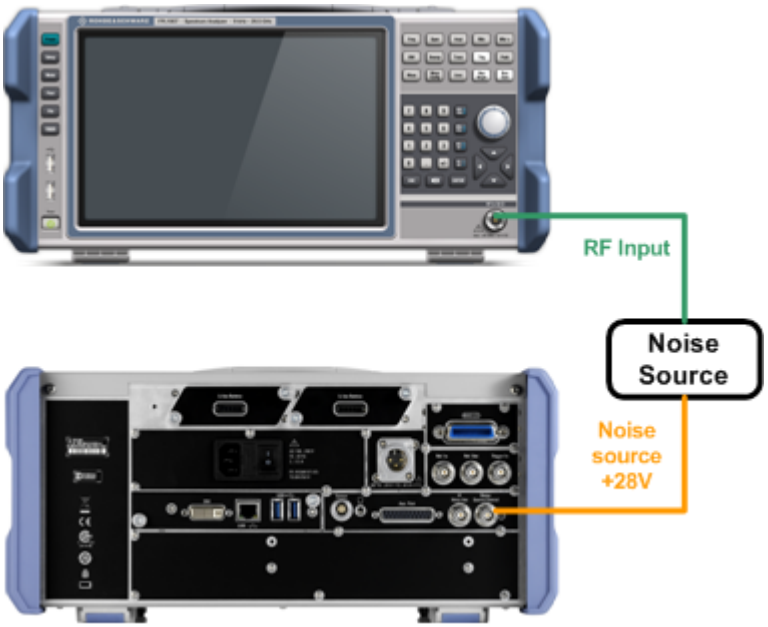


Figure 4-1: Noise figure calibration setup

1. Connect the noise source directly and without a cable to the RF input of the analyzer.
2. Connect the noise source to the +28 V voltage supply (Noise Source Control connector) on the back of the R&S ZNL.
   To connect the noise source to the voltage supply, you need a coaxial cable.

After you have set up calibration, there are several ways to start calibration.

- In the "Noise Overview" dialog box, press the "Calibrate" button.
- In the "Sweep" menu, press the "Calibrate" softkey.

Calibration Save

Calibration Save

If the user has performed a valid calibration on the instrument, the calibration results can be saved by using the "Calibration Save" button in the "Export" dialog. This provides the possibility to use once stored calibration results at a later point.

Remote command:
[SENSe:]CORRection:SAVE on page 130

Calibration Recall

Calibration Recall

Calibration results that have been stored once on the instrument can be recalled by using the "Calibration Recall" button in the "Import" dialog.

To achieve a valid calibration by importing a saved one, all parameters of R&S ZNL-K30 must match exactly to the ones that have been used for the calibration. At the import of a calibration, a preview dialog is shown which contains all relevant parameters of the calibration to be imported and an indication (green / red) if they match to the current instrument and option settings. Only if the calibration context summary is green, the calibration import can be done. If the calibration context summary is red, importing the calibration results would lead to an invalid calibration status for the current settings. Thus the calibration results cannot be imported in this case. If the calibration context summary is green but some of the individual entries are red (i.e. they differ from the current settings), the calibration results still can be imported. The import will then overwrite the red marked settings with the ones from the stored calibration to ensure the settings match.

Remote command:
[SENSe:]CORRection:RECall on page 130

4.6 Using smart noise sources

A smart noise source (SNS) provides its own ENR and uncertainty tables and a temperature value from an internal measurement. Thus, accuracy is improved and less configuration efforts are required.

When you connect a smart noise source, the R&S ZNL automatically loads its ENR table and stores it for future measurements. The ENR table remains stored on the instrument even after the noise source is disconnected. If the table already exists on the R&S ZNL, the contents are updated, if necessary. The contents of the most recently loaded SNS ENR table are also stored as the "default" ENR table. Thus, they remain available even if the noise source type is changed, for example to "noise diode". The ENR tables for smart noise sources are shown for reference only and cannot be edited in the R&S FPL1 Noise Figure measurements application. The name of each ENR table contains the serial number of the SNS.

Test Setup

Connect the smart noise source to the Lemosa Power Sensor / Noise Source Control connector on the R&S ZNL. (For models without a Lemosa connector, connect the SNS to the BNC Noise source control connector and a USB connector on the R&S ZNL.) Then connect the SNS output to the DUT or the RF Input connector on the R&S ZNL. Only one SNS can be active on the R&S ZNL at any time.

The identification and setup procedure after connecting the FS-SNS may take up to 10 seconds.

4.7 Separating signals by selecting an appropriate resolution bandwidth

The resolution bandwidth defines the 3 dB bandwidth of the resolution filter to be used. An RF sinusoidal signal is displayed according to the passband characteristic of the resolution filter (RBW), i.e. the signal display reflects the shape of the filter.

The highest sensitivity is obtained at the smallest bandwidth (1 Hz). If the bandwidth is increased, the reduction in sensitivity is proportional to the change in bandwidth. Increasing the bandwidth by a factor of 3 increases the displayed noise by approx. 5 dB (4.77 dB precisely). If the bandwidth is increased by a factor of 10, the displayed noise increases by a factor of 10, i.e. 10 dB.

The higher spectral resolution with smaller bandwidths is won by longer sweep times for the same span. The sweep time has to allow the resolution filters to settle during a sweep at all signal levels and frequencies to be displayed.

If the RBW is too large, signal parts that are very far away (e.g. from a different signal) are considered in the measurement and distort the results. The displayed noise increases.

If the RBW is too small, the measurement time increases.

Variable RBW and sweep time for low-frequency measurements

Usually, a constant RBW and sweep time is used for the entire measurement. However, for low-frequency measurements (under 10 MHz), smaller bandwidths and longer sweep times are required to improve accuracy of the results. Using a small RBW and long sweep time for the entire span would increase measurement time significantly. In this case, a variable RBW and sweep time can be defined for lower frequencies, depending on the current frequency of the sweep point. The variable RBW and sweep times are defined in the frequency table (see Chapter 5.2.3, "Using a frequency table", on page 47). The defined RBW and sweep times are also included in a table export. In the channel bar, the bandwidth and sweep time range of the variable values is indicated.

4.8 Analyzing several traces - trace mode

The trace mode determines the way the data is processed and displayed. The application provides the following trace modes.

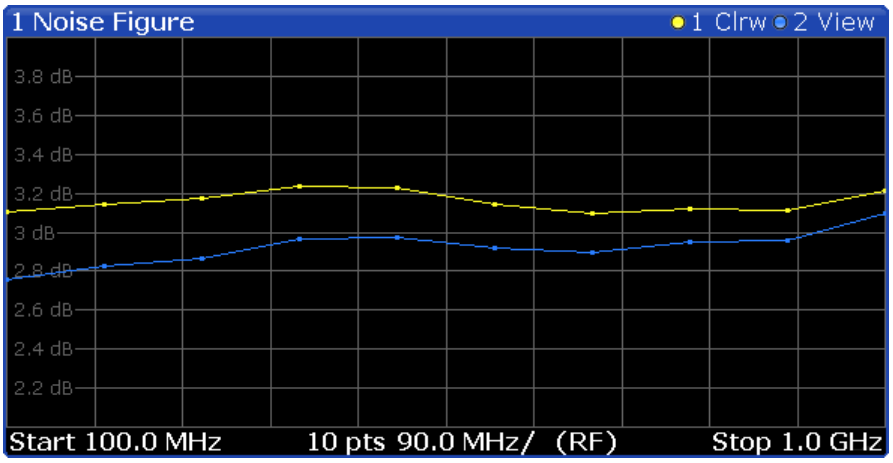
Table 4-1: Overview of available trace modes

Trace Mode	Description
Blank	Hides the selected trace.
Clear Write	Overwrite mode: the trace is overwritten by each sweep. This is the default setting.
View	The current contents of the trace memory are frozen and displayed.

Each time the trace mode is changed, the selected trace memory is cleared.

The default trace mode for the first trace is Clear/Write. For trace 2-4, the default trace mode is "Blank". If you require another mode, you have to set it manually.

As you can have up to four traces simultaneously, you can compare the results with different measurement configurations. For example, freeze a trace and use it as a reference trace.



If you change the scaling of the y-axis, the R&S ZNL automatically adapts the trace data to the changed display range. Thus, you can perform an amplitude zoom after the measurement to show details of the trace.

4.9 Using markers

Markers are used to mark points on traces, to read out the results of a particular measurement point or compare results of different traces. The noise application provides four markers.

When you activate a marker, the application automatically positions it on the first measurement point (left border of the diagram) of trace 1, regardless of how many traces are active. A marker is always positioned on the same horizontal position in all active measurement windows. If you change the position of a marker in one window, the application adjusts the position of that marker in all other measurement windows. Thus, the marker results for a specific marker are always for the same frequency, which makes it easier to compare results.

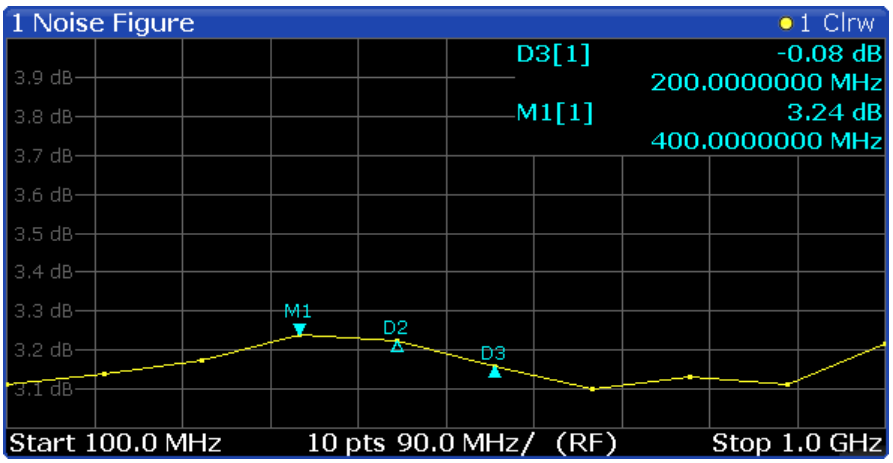
Markers in single frequency mode

When you use a marker for single frequency measurements, the marker is positioned on a particular index value and not a particular measurement point. This means that during continuous measurements, the marker remains on the index value you have put it on. It does not move down the line with the results.

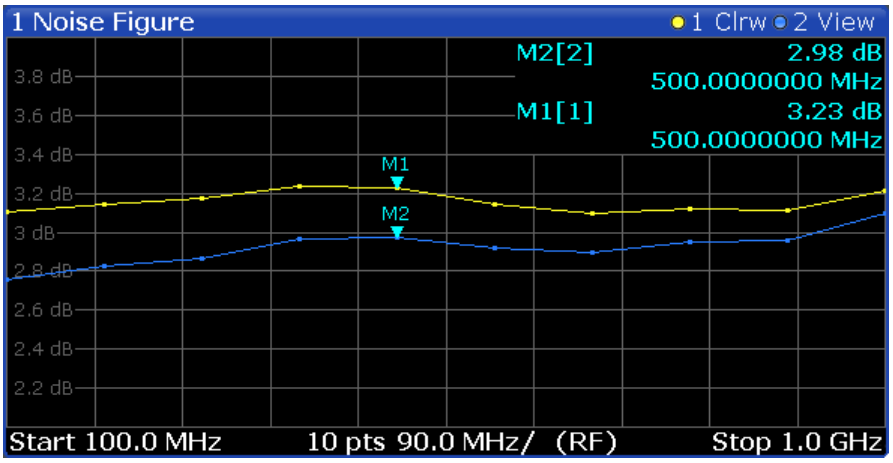
To move a marker, you can use several methods.

- Enter a particular measurement frequency in the input field that opens when you activate a marker.
- Move the marker around with the rotary knob or the cursor keys.
- Drag the marker around using the touchscreen.

All markers can be used either as normal markers or delta markers. A normal marker indicates the absolute signal value at the defined position in the diagram. A delta marker indicates the value of the marker relative to the specified reference marker (by default marker 1).



The application always positions the marker on the trace with the lowest number that is in Clear/Write trace mode. To set the marker on another trace, use the "Marker to Trace" function. With this function, you can also position a marker on a trace that is in "View" trace mode, e.g. to compare measurement results. Note that at least one active marker has to be a normal marker.



The application shows the results at the marker position directly in the diagram area (up to two markers) or in the marker table (if you use more than two markers).

Marker information in diagram area

By default, the results of the last two markers or delta markers that were activated are displayed in the diagram area.

The following information is displayed there:

- The marker type (M for normal, D for delta, or special function name)
- The marker number (1 to 4)

- The assigned trace number in square brackets [ ]
- The marker value on the y-axis
- The marker position on the x-axis

Marker information in marker table

In addition to the marker information displayed within the diagram area, a marker table can be displayed in a separate window. For more information on the contents of the marker table, see "Marker Table" on page 23.

5 Configuration

"Noise figure" measurements require a special application on the R&S ZNL, which you activate using the [MODE] key.

The Noise Source Control connector on the R&S ZNL is also a prerequisite for the R&S FPL1 Noise Figure measurements application. Without this connector, no measurement can be performed.

This connector is part of the "Additional Interfaces" hardware option R&S FPL1-B5.

You must explicitly activate the use of this connector in the rear panel aux port configuration settings ([Setup] > "System Config" > "Add. Interfaces" > "SA (Aux 5V)"). Make sure a compatible device is connected to the interface before you activate it, to avoid damage to the connected device.

See the R&S ZNL User Manual, "General Instrument Setup".

If the Noise Source Control connector is not enabled, a warning is displayed in the R&S FPL1 Noise Figure measurements application status bar indicating that the noise source control is disabled.

When you activate a measurement channel in the R&S FPL1 Noise Figure measurements application, a measurement for the input signal is defined with the default configuration. The "Noise Figure" menu is displayed and provides access to the most important configuration functions.

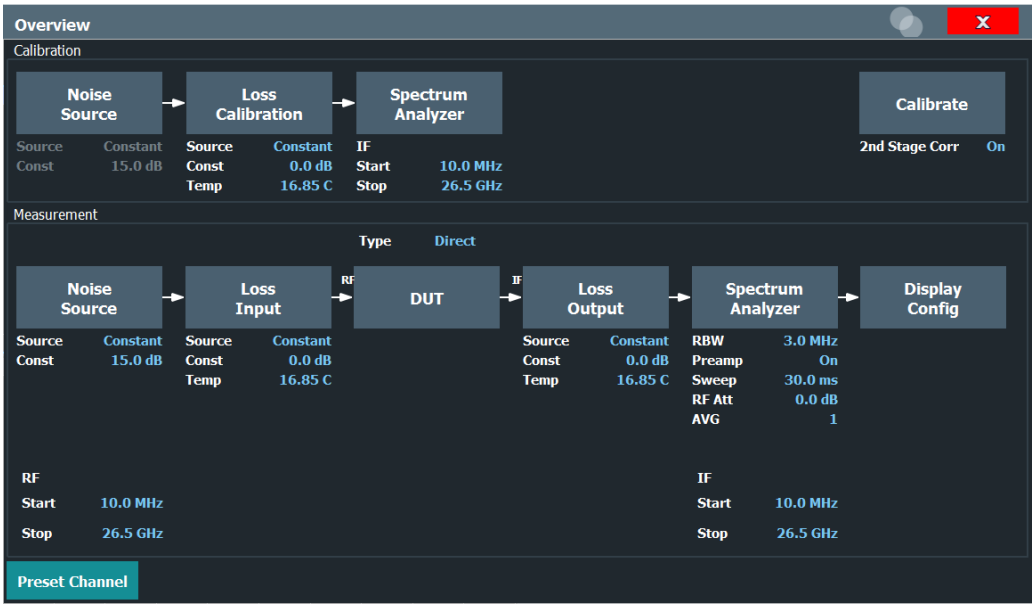
Unavailable hardkeys

Note that the [AMPT], [BW], and [TRIG] keys have no contents and no function in the R&S FPL1 Noise Figure measurements application.

- Configuration overview....41
- Defining the measurement frequency....43
- Selecting DUT characteristics....50
- Configuring the noise source....51
- Configuring additional loss....59
- Configuring the analyzer....64
- Using the uncertainty calculator....67
- Performing measurements....74
- Configuring inputs and outputs of the R&S ZNL....75

5.1 Configuration overview

Throughout the measurement channel configuration, an overview of the most important currently defined settings is provided in the "Overview". The "Overview" is displayed when you select the "Overview" icon, which is available at the bottom of all softkey menus.



In addition to the main measurement settings, the "Overview" provides quick access to the main settings dialog boxes. The individual configuration steps are displayed in the order of the data flow. Thus, you can easily configure an entire measurement channel from input over processing to output and analysis by stepping through the dialog boxes as indicated in the "Overview".

In particular, the "Overview" provides quick access to the following configuration dialog boxes (listed in the recommended order of processing):

To perform a calibration

1. Noise Source
   See Chapter 5.4, "Configuring the noise source", on page 51.
2. Spectrum Analyzer
   See Chapter 5.6, "Configuring the analyzer", on page 64.
3. Calibration
   See "Calibrate" on page 75

To perform a measurement

1. Noise Source
   See Chapter 5.4, "Configuring the noise source", on page 51.
2. Input and output losses
   See Chapter 5.5, "Configuring additional loss", on page 59.
3. DUT configuration
   See Chapter 5.3, "Selecting DUT characteristics", on page 50
4. Spectrum Analyzer
   See Chapter 5.6, "Configuring the analyzer", on page 64.
5. Display Configuration

See Chapter 6.1, "Configuring the display", on page 77

To configure settings

► Select any button in the "Overview" to open the corresponding dialog box.
Select a setting in the channel bar (at the top of the measurement channel tab) to change a specific setting.

Preset Channel Setup
Select the "Preset Channel" button in the lower left-hand corner of the "Overview" to restore all measurement settings *in the current channel setup* to their default values.

Note: Do not confuse the "Preset Channel" button with the [Preset] *key*, which restores the entire instrument to its default values and thus closes *all channel setups* on the R&S ZNL (except for the default channel setup)!

Remote command:
`SYSTem:PRESet:CHANnel[:EXEC]` on page 98

Specifics for
The channel setup can contain several windows for different results. Thus, the settings indicated in the "Overview" and configured in the dialog boxes vary depending on the selected window.

Select an active window from the "Specifics for" selection list that is displayed in the "Overview" and in all window-specific configuration dialog boxes.

The "Overview" and dialog boxes are updated to indicate the settings for the selected window.

5.2 Defining the measurement frequency

- Defining a frequency set 43
- Configuring single frequency measurements 46
- Using a frequency table 47

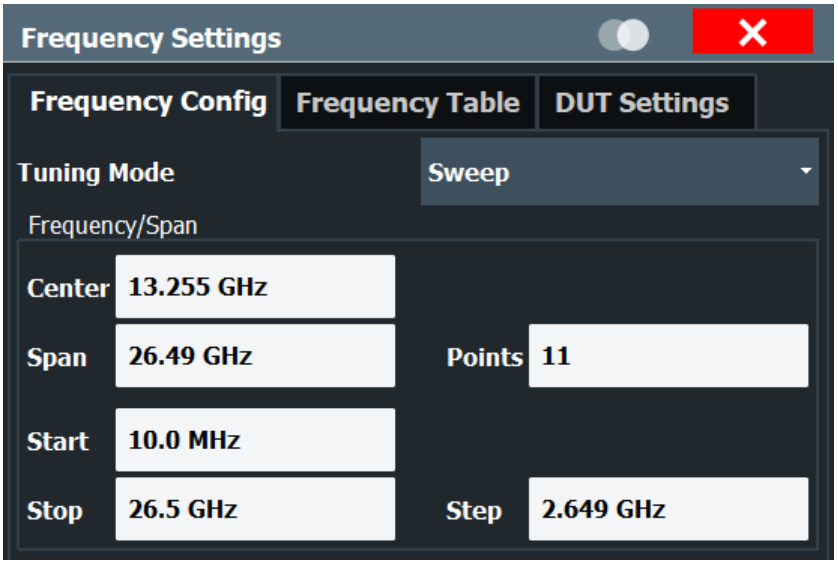
5.2.1 Defining a frequency set

Access: "Overview" > "DUT" > "Frequency Config"

These settings define the frequency characteristics for the measurement.

The information in this tab is also the basis for an automatic population of the frequency table. All parameters of this dialog are interdependent. If you change one parameter, at least one other parameter is changed by the application.

If you change a frequency set, perform a new calibration to ensure accurate results.



Tuning Mode 44
Center 45
Span 45
Start and Stop Frequency 45
(Measurement) Points 45
Step 45

Tuning Mode
Selects the tuning or measurement mode.

For more information, see Chapter 4.1, "Tuning modes", on page 24.

Tuning mode selection is also available via softkeys ("Sweep Mode", "Frequency Table Mode", "Single Frequency Mode") in the "Sweep" menu.

"Sweep"	The measurement is based on an automatically generated frequency set.
"Frequency Table"	The measurement is based on a customized frequency table. For more information, see Chapter 5.2.3, "Using a frequency table", on page 47.
"Single Frequency"	The measurement measures a single frequency only. For more information, see Chapter 5.2.2, "Configuring single frequency measurements", on page 46.

Remote command:
Frequency sweep measurement:
`[SENSe:]CONFigure:LIST:CONTinuous` on page 108
`[SENSe:]CONFigure:LIST:SINGle` on page 108
`INITiate<n>[:IMMediate]` on page 145
Single frequency measurement:
`[SENSe:]CONFigure:FREQuency:CONTinuous` on page 107
`[SENSe:]CONFigure:FREQuency:SINGle` on page 108
`INITiate<n>[:IMMediate]` on page 145

Center
Defines the center of the measurement frequency range.

If you change the center frequency, the application changes the start and stop frequency according to the span you have set.

The "Center" setting is also available via the [FREQ] key.

Remote command:
Frequency list measurement:
`[SENSe:]FREQuency:CENTer` on page 108
Single frequency measurement:
`[SENSe:]FREQuency:SINGle` on page 110

Span
Defines the measurement span.

If you change the span, the application changes the start frequency, the stop frequency and the stepsize according to the center frequency and the measurement points.

The "Span" setting is also available via the [SPAN] key.

Remote command:
`[SENSe:]FREQuency:SPAN` on page 111

Start and Stop Frequency
Defines the start and stop frequencies.

If you change the start or stop frequency, the application changes the center frequency, the span and the measurement points according to the new values and the stepsize.

The "Start" and "Stop" settings are also available via the [FREQ] key.

Remote command:
Start frequency:
`[SENSe:]FREQuency:STARt` on page 111
Stop frequency:
`[SENSe:]FREQuency:STOP` on page 111

(Measurement) Points
Defines the measurement points.

For frequency list measurements, the number of measurement points corresponds to the number of entries in the frequency table. The number of points displayed in the graphical results is also the same.

If you change the measurement points, the application changes the stepsize according to the span.

The "Points" setting is also available via the [SPAN] key.

Remote command:
`[SENSe:]FREQuency:POINts` on page 110

Step
Defines the frequency step size in the frequency table.

The stepsize corresponds to the distance between two consecutive measurement points.

If you change the stepsize, the application changes the measurement point according to the span.

The "Stepsize" setting is also available via the [FREQ] key.

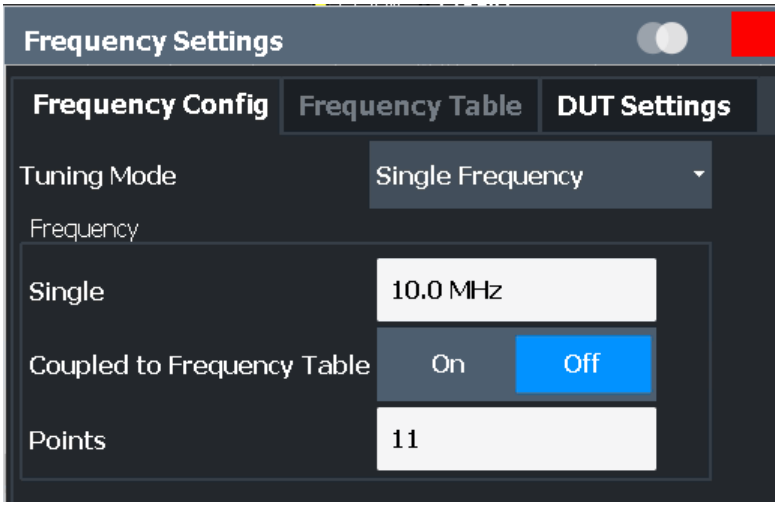
Remote command:
`[SENSe:]FREQuency:STEP` on page 111

5.2.2 Configuring single frequency measurements

Access: "Overview" > "DUT" > "Frequency Config" > "Tuning Mode: Single Frequency"

These settings define the frequency characteristics for the measurement.

If you change the frequency, perform a new calibration to ensure accurate results.



Single (Frequency)....46
Coupled to Sweep List....46
(Measurement) Points....47

Single (Frequency)
Defines the frequency that the single frequency measurement is performed on.

The "Single" setting is also available via the [FREQ] key.

Remote command:
`[SENSe:]FREQuency:SINGle` on page 110

Coupled to Sweep List
Couples or decouples frequency selection to the contents of a sweep list.

If you couple the frequency to the sweep list, the application allows you to select only the frequencies currently part of the frequency list. If you enter another frequency, the application automatically selects the nearest frequency of the frequency list. If the frequency list has been calibrated previously, calibration remains valid for those frequencies when you change the tuning mode.

If you turn off the coupling, you can define any frequency for single frequency measurements. Note, however, that you have to calibrate the measurement for that frequency.

Remote command:
`[SENSe:]FREQuency:SINGle:COUPled` on page 110

(Measurement) Points
Defines the number of measurement points for single frequency measurements.

For single frequency measurements, the number of measurement points corresponds to the number of measurements (index values) performed on a single frequency.

For more information, see "Single frequency measurements" on page 16.

The "Points" setting is also available via the [SPAN] key.

Remote command:
`[SENSe:]FREQuency:POINts` on page 110

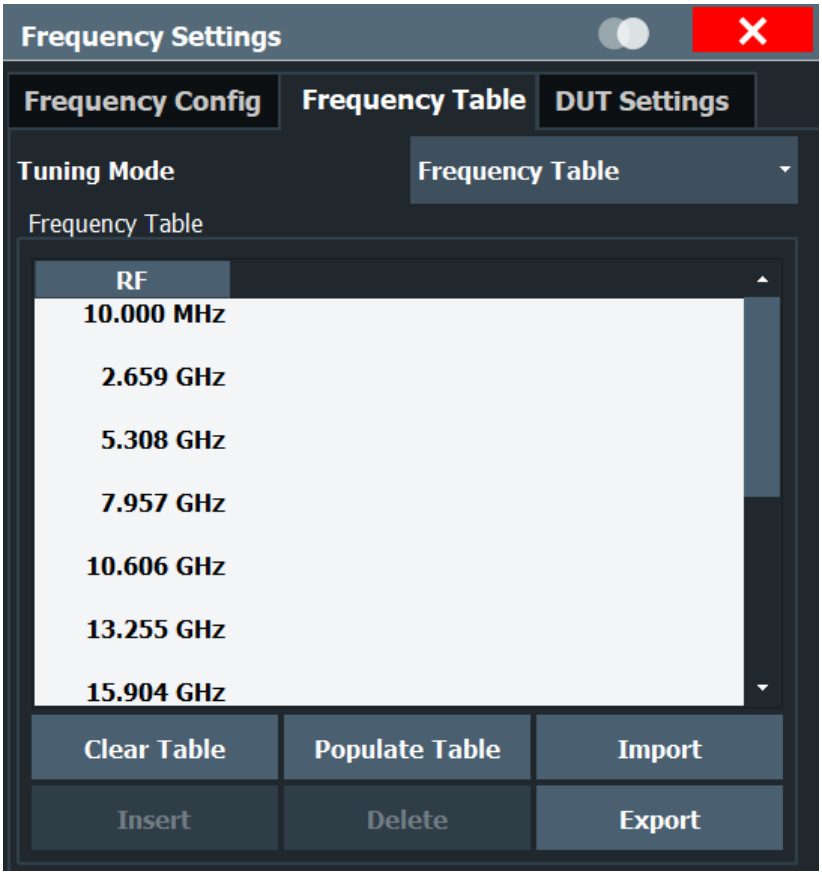
5.2.3 Using a frequency table

Access: "Overview" > "DUT" > "Frequency Config" > " Frequency Table"

The "Frequency Table" tab in the "Frequency Settings" dialog box contains functionality to manage the measurement frequencies.

The application populates the table according to the information you entered in the "Frequency Config" tab when you select "Populate Table".

Note that changes to the frequency table take effect only if you select the "Frequency Table" tuning mode.



Frequency Table....48
Clear Table....49
Populate Table....49
Insert....49
Delete....49
Import / Export....49

Frequency Table
Shows the current measurement points.

The table is made up of one column that represents the measurement frequency. Each frequency corresponds to one measurement point. The length of the table is variable (up to a maximum of 10001 points).

When you perform measurements in "Sweep" or "Single Frequency" tuning mode, the contents of the table have no effect on the measurement.

When you select a table entry in "Frequency Table" tuning mode, you can edit it or add a new frequency below the selected frequency. A new frequency has to be higher than the last table entry and lower than the next table entry.

If the RBW and sweep time settings are set to "variable" in the measurement settings (see Resolution Bandwidth (RBW) and "Sweep Time" on page 65), you can also define those values in the frequency table.

Select Populate Table to predefine the RBW and sweep times to be used. For each sweep point with a frequency under 10 MHz in the table, suitable settings are defined. For higher frequencies, the values provided in the measurement settings are used (indicated by "--" as they are automatically updated if the measurement settings change.) All predefined values in the table can be overwritten manually.

The defined RBW and sweep times are also included in a table export.

See also "Variable RBW and sweep time for low-frequency measurements" on page 37.

Clear Table
Deletes the contents of the table.

Populate Table
Populates or restores the measurement frequencies based on the center frequency, the start and stop frequencies, the span, the stepsize and the number of measurement points.

If the RBW and sweep time settings are set to "variable" in the measurement settings (see Resolution Bandwidth (RBW) and "Sweep Time" on page 65), those values are also predefined. For each sweep point with a frequency under 10 MHz in the table, suitable settings are defined. For higher frequencies, the values provided in the measurement settings are used (indicated by "--" as they are automatically updated if the measurement settings change.) All predefined values in the table can be overwritten manually.

See also "Variable RBW and sweep time for low-frequency measurements" on page 37.

Remote command:
`[SENSe:]FREQuency:TABLe:DATA` on page 109
`[SENSe:]FREQuency:LIST:DATA` on page 109
RBW and sweep time set to variable: `[SENSe:]BANDwidth:LIST:DATA` on page 109

Insert
Inserts a new measurement point above the one you have selected.

Delete
Deletes the currently selected measurement point.

Import / Export
Opens a dialog box to select a frequency table to import or export.

An import copies the frequency table into the default frequency table directory. An export copies the table to a location outside the default frequency table directory, e.g. a memory stick. The file extension has to be `*.freq`.

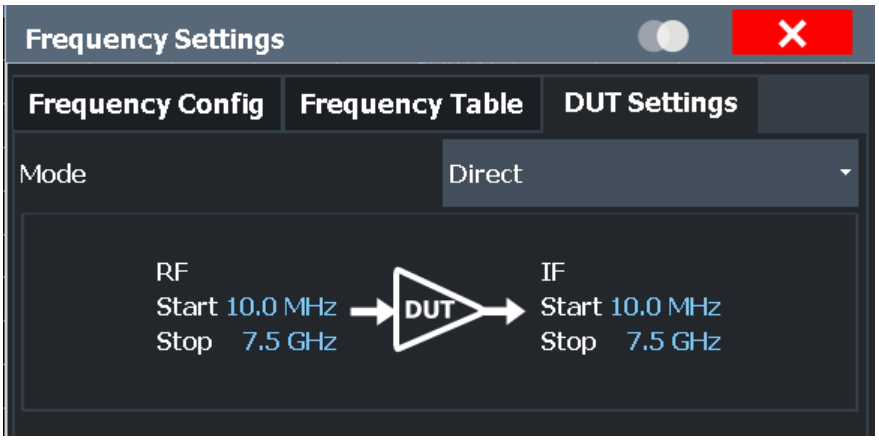
If variable RBW and sweep times are enabled, they are also included in a table export (see "Frequency Table" on page 48).

For details on the required file format, see Chapter A, "Reference: frequency table file format", on page 184.

5.3 Selecting DUT characteristics

Access: "Overview" > "DUT" > "DUT Settings"

The "DUT" button opens a dialog box to configure the characteristics of the DUT you are testing. The dialog box contains a schematic overview of the DUT input and output characteristics and the way it is integrated into the test setup.



Mode 50
LO Fixed 50
Image Rejection 50

Mode
Selects the measurement mode.

The required measurement mode depends on the type of DUT you are testing. For more information, see Chapter 4.3, "DUT types", on page 29.

Remote command:
DUT type: `[SENSe:]CONFigure:MODE:DUT` on page 113
LO type: `[SENSe:]CONFigure:MODE:SYSTem:LO` on page 112

LO Fixed
Defines a fixed LO frequency for measurements on frequency-converting DUTs with a fixed LO.

After you have defined the LO frequency, the application updates the frequency list accordingly.

The "LO" setting is also available via the [FREQ] key.

Remote command:
`[SENSe:]CONFigure:MODE:SYSTem:LO:FREQuency` on page 112

Image Rejection
Turns image rejection of the DUT on and off.

If you set an image rejection of 0 dB, the image frequency passes completely. If you set a high image rejection (up to 999.99 dB), the image frequency is suppressed completely. For DUTs that have a partial image rejection, define the amount of suppression.

For more information, see Chapter 4.4, "Image frequency rejection", on page 30.

Remote command:
`[SENSe:]CORRection:IREJection` on page 113

5.4 Configuring the noise source

The noise source characteristics are used to calculate the effective "noise temperature" of the noise source. The more accurate the specified characteristics of the noise source you are using, the more accurate the measurement results. The noise source characteristics must be supplied by its manufacturer.

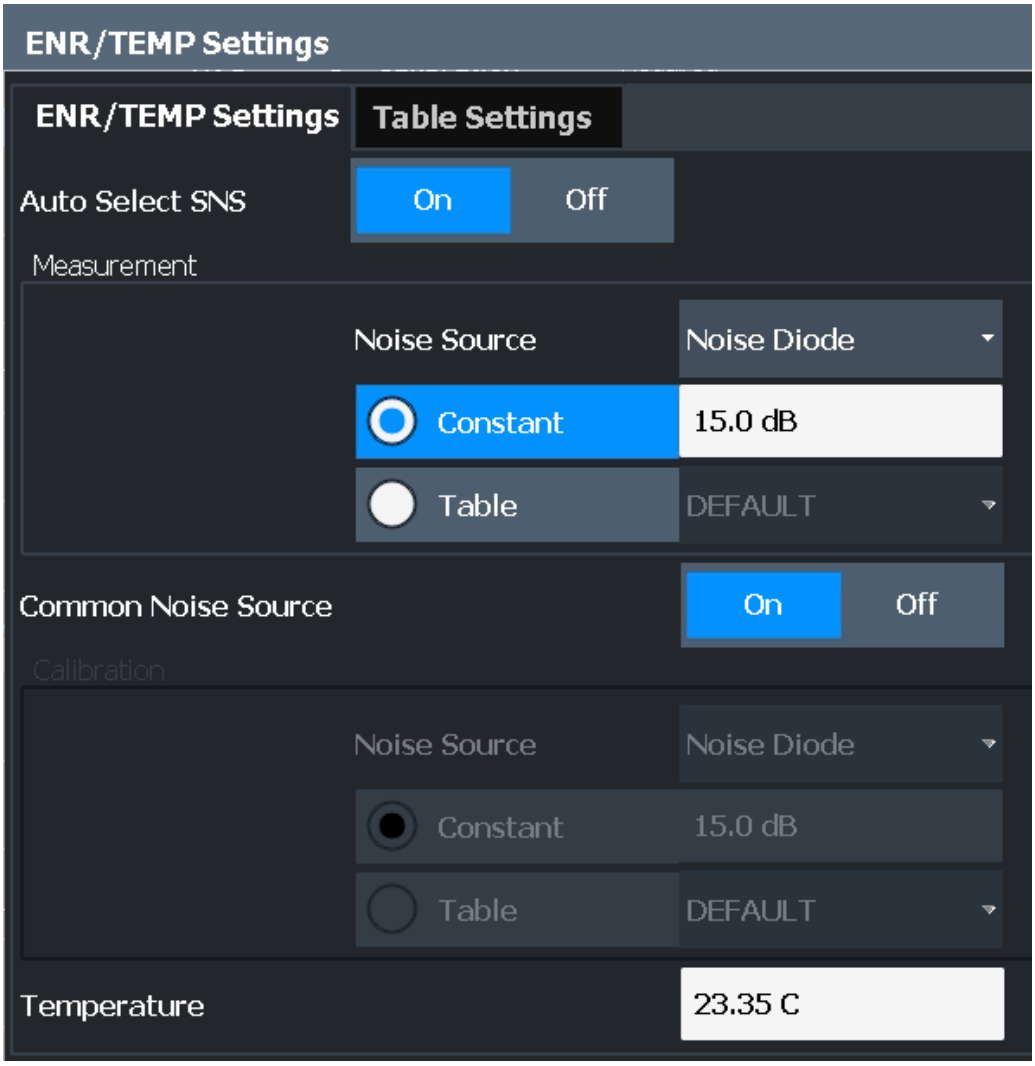
- Defining the noise source characteristics.....51
- Using an ENR or temperature table.....55

5.4.1 Defining the noise source characteristics

Access: "Overview" > "Noise Source" > "ENR / Temp Settings"

The noise characteristics of noise sources with diode characteristics are usually defined by their ENR (Excess Noise Ratio). The noise characteristics of noise sources with resistor characteristics are defined by their noise (or ambient) temperatures (T_{hot} and T_{cold}). T_{cold} is typically at a very low temperature of liquid nitrogen or liquid helium.

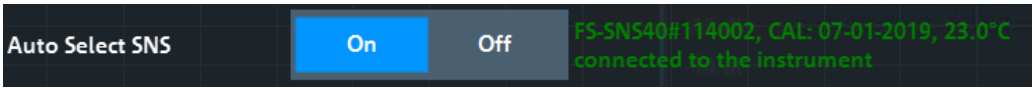
Both noise source types can have different ENR values during the calibration and the measurement stage. You can use either the same type of noise source for both calibration and measurement, or use different types of noise sources for calibration and measurement.



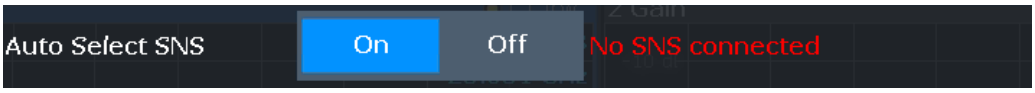
Auto Select SNS 52
Noise Source 53
Measurement 53
Common Noise Source 54
Calibration 54
Temperature 55

Auto Select SNS
If enabled (default), the R&S FPL1 Noise Figure measurements application automatically recognizes a connected smart noise source and uses it for the noise measurement. The provided ENR and uncertainty tables and temperature are loaded and used for the measurement. The recognized serial number of the SNS is indicated in the channel bar and dialogs of the R&S FPL1 Noise Figure measurements application.

If "Auto Select SNS" is ON and a SNS is connected, a green message with information about the connected SNS is displayed:



If no SNS is connected, a red "No SNS connected" warning is displayed:



If "Auto Select SNS" is disabled, you must manually change the noise source to SNS and select the required tables, if necessary (see "Frequency Table" on page 48).

Noise Source
Access: "Overview" > "Noise Source" > "ENR / Temp Settings" > "Noise Source"

You can select the type of noise source and its characteristics independently for the Calibration and the Measurement.

"Diode" Selects a noise source with diode characteristics. The frequency characteristics of the noise source are defined by the Excess Noise ratio (ENR).

"Resistor" Selects a test setup that uses two resistors which act as a noise source. One of the resistors has a low noise or ambient temperature (a cold resistor), the other has a high noise or ambient temperature (a hot resistor). The noise characteristics of the resistor are defined by its "noise temperatures" T_{hot} and T_{cold}.
When you select the resistor noise source, the application automatically starts the manual measurement mode, which is indicated in a message at the bottom of the dialog box.

"Smart Noise Source" Selects a smart noise source, which provides its own ENR and uncertainty tables. The serial number of the connected noise source is automatically recognized and indicated. Otherwise, enter the number of a noise source to continue preconfiguring the measurement.

Remote command:
Measurement: `[SENSe:]CORRection:ENR[:MEASurement]:TYPE` on page 119
`[SENSe:]CORRection:ENR[:MEASurement]:SNS:SRNumber` on page 121
Calibration: `[SENSe:]CORRection:ENR:CALibration:TYPE` on page 116
`[SENSe:]CORRection:ENR:CALibration:SNS:SRNumber` on page 121

Measurement
Selects the source of the ENR or temperature values.

The frequency characteristics can be approximated by a constant or be based on an ENR or temperature table.

If the ENR or temperature is a constant, the same values are used for all frequencies in the frequency table. If you have selected a constant ENR, you have to define its magnitude in the input field next to the radio button. If you have selected a constant temperature, you have to define the temperatures of the resistor in the input fields next to the radio button. T_{hot} is the temperature of a resistor with a low noise or ambient temperature; T_{cold} is the temperature of a resistor with a high noise or ambient temperature.

If the noise characteristics are based on a table, the ENR level and temperatures typically depend on the measurement frequency. You can select an existing table from the dropdown menu next to the radio button, if it is active. For more information on ENR and temperature tables, see Chapter 5.4.2, "Using an ENR or temperature table", on page 55.

When "Common Noise Source" is on, the ENR is used for both measurement and calibration.

Remote command:
ENR mode: `[SENSe:]CORRection:ENR[:MEASurement]:MODE` on page 119
Constant ENR: `[SENSe:]CORRection:ENR[:MEASurement]:SPOT` on page 119
Select table: `[SENSe:]CORRection:ENR[:MEASurement]:TABLe:SELect` on page 118
Constant temperature: `[SENSe:]CORRection:ENR[:MEASurement]:SPOT:COLD` on page 120
Constant temperature: `[SENSe:]CORRection:ENR[:MEASurement]:SPOT:HOT` on page 120

Common Noise Source
Turns the use of a common ENR on and off.

Common ENRs have the same characteristics for the measurement and calibration. If you turn off common ENR, you can define an additional ENR to be used during calibration.

Define additional ENR for measurements on frequency converting DUTs, if one noise source does not cover the frequency range at the DUT input (RF) and for calibration (IF).

Remote command:
`[SENSe:]CORRection:ENR:COMMon` on page 116

Calibration
Selects the source of the ENR or temperature values used during calibration.

The frequency characteristics can be a constant or be based on an ENR or temperature table.

If the ENR or temperature is a constant, the same value is used for all frequencies in the frequency table. If you have selected a constant ENR, you can also define its value in the input field next to the radio button. If you have selected a constant temperature, you have to define the temperatures of the resistor in the input fields next to the radio button. T_{hot} is the temperature of a resistor with a low noise or ambient temperature; T_{cold} is the temperature of a resistor with a high noise or ambient temperature.

If the noise source characteristics are based on a table, the ENR level and temperature depend on the measurement frequency. In that case, the values are interpolated to the measurement points. You can select a table from the dropdown menu next to the radio button, if it is active. For more information on ENR tables, see Chapter 5.4.2, "Using an ENR or temperature table", on page 55.

The calibration settings are available if the "Common Noise Source" is off.

Remote command:
ENR mode: [SENSe:]CORRection:ENR:CALibration:MODE on page 115
Constant ENR: [SENSe:]CORRection:ENR:CALibration:SPOT on page 115
Select table: [SENSe:]CORRection:ENR:CALibration:TABLe:SELect on page 115
Constant temperature: [SENSe:]CORRection:ENR:CALibration:SPOT:COLD on page 114
Constant temperature: [SENSe:]CORRection:ENR:CALibration:SPOT:HOT on page 114

Temperature
Defines the absolute room temperature in degree Celsius or Fahrenheit.

The room temperature is required for the calculation of the real ENR of the noise source, because an ENR table is based on a temperature of 290K.

For smart noise sources, the temperature is provided automatically by the connected SNS itself. If no SNS is connected, the most recently loaded value is indicated. The provided temperature is used for all noise sources throughout the measurement.

To change the unit of the temperature from Celsius to Fahrenheit, change the date format from "DE" to "US" in the "General" display settings.

- Press the [SETUP] key.
- Select "Display".
- Select the "General" tab.
- Select "DE" for Celsius or "US" for Fahrenheit.

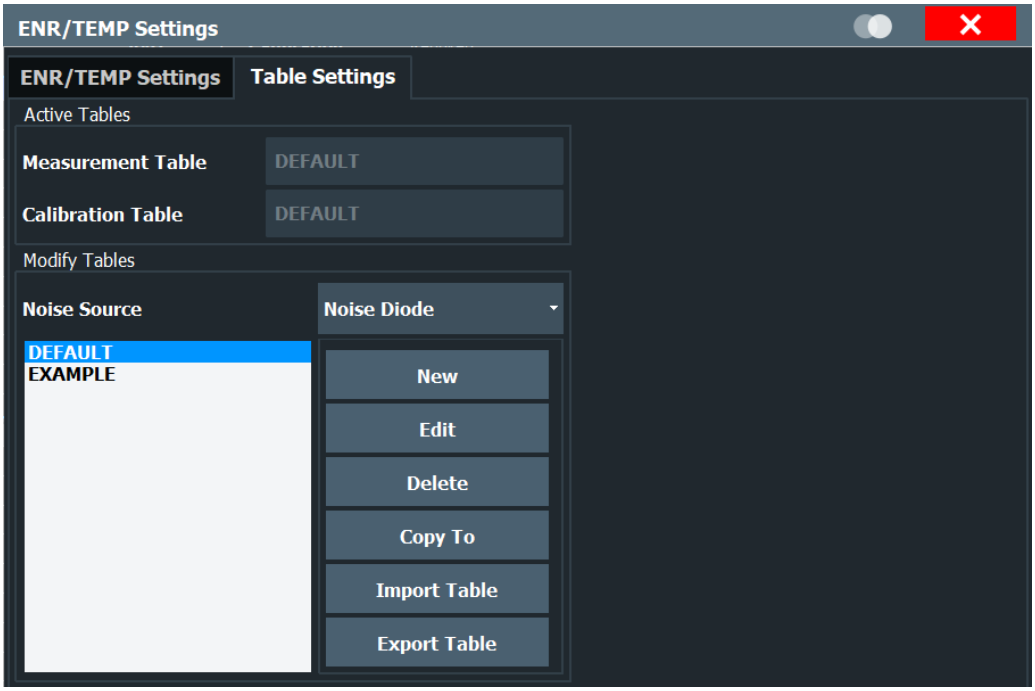
Note: If you define the temperature via remote control, the unit is degree Kelvin.

Remote command:
[SENSe:]CORRection:TEMPerature on page 121

5.4.2 Using an ENR or temperature table

Access: "Overview" > "Noise Source" > "Table Settings"

The "Table Settings" tab in the "ENR/TEMP Settings" dialog box contains the functionality to create and edit ENR or temperature tables.



ENR or temperature tables contain the noise source characteristics for particular frequencies. If the table does not contain ENR or temperature values for one of the measurement frequencies, the application interpolates between the values.

The "Table Settings" tab contains a list of ENR and temperature tables currently available on the R&S ZNL and shows the table currently in use if the "ENR/TEMP Settings" are enabled.

In addition, the tab contains functionality to create new tables and modify existing ones.

Noise Source....56
New....57
Edit....57
Delete....57
Copy To....58
Import / Export Table....58
Edit Table....58

Noise Source
Selects the type of noise source you are using for the measurement. The type of noise source selected in the "ENR/TEMP Settings" > "Noise Source" dialog is adopted automatically.

The noise source type affects the data type that the table contains. For a "Noise Diode", the table contains the ENR values of the noise source you are using. For a "Resistor", the table contains the "noise temperatures" of the resistors (T_{hot} and T_{cold}).

For a smart noise source, the table contains the provided ENR and uncertainty table. The table for the connected noise source is automatically recognized and highlighted. The name of the ENR table contains the serial number of the SNS. The "default" table also contains the data for the most recently connected smart noise source. The tables for all previously connected noise sources, whose ENR tables remain stored on the instrument, are also listed. Smart noise source tables are for reference only and cannot be edited.

For more information on the noise source types, see "Noise Source" on page 53.

Remote command:
`[SENSe:]CORRection:ENR[:MEASurement]:TYPE` on page 119

New
Opens the Edit Table dialog box to create a new table.

The contents of the dialog box are empty.

Smart noise source tables are shown for reference only and cannot be edited. A message indicates whether the SNS with the selected serial number is currently connected to the R&S ZNL or not. If it is connected, the table data reflects the most recent data provided by the SNS.

Remote command:
Table selection: `[SENSe:]CORRection:ENR:CALibration:TABLe:SELect` on page 115
and: `[SENSe:]CORRection:ENR[:MEASurement]:TABLe:SELect` on page 118
Diode: `[SENSe:]CORRection:ENR[:MEASurement]:TABLe[:DATA]` on page 117
Resistor: `[SENSe:]CORRection:ENR[:MEASurement]:TABLe:TEMPerature[:DATA]` on page 118

Edit
Opens the Edit Table dialog box to modify the selected table.

Smart noise source tables are for reference only and cannot be edited.

Remote command:
Table selection: `[SENSe:]CORRection:ENR[:MEASurement]:TABLe:SELect` on page 118
and: `[SENSe:]CORRection:ENR[:MEASurement]:TABLe:SELect` on page 118
Diode: `[SENSe:]CORRection:ENR[:MEASurement]:TABLe[:DATA]` on page 117
Resistor: `[SENSe:]CORRection:ENR[:MEASurement]:TABLe:TEMPerature[:DATA]` on page 118

Delete
Deletes the selected table.

Smart noise source tables cannot be deleted.

Remote command:
Diode: `[SENSe:]CORRection:ENR[:MEASurement]:TABLe:DELete` on page 117
Resistor: `[SENSe:]CORRection:ENR[:MEASurement]:TABLe:TEMPerature:DELete` on page 118

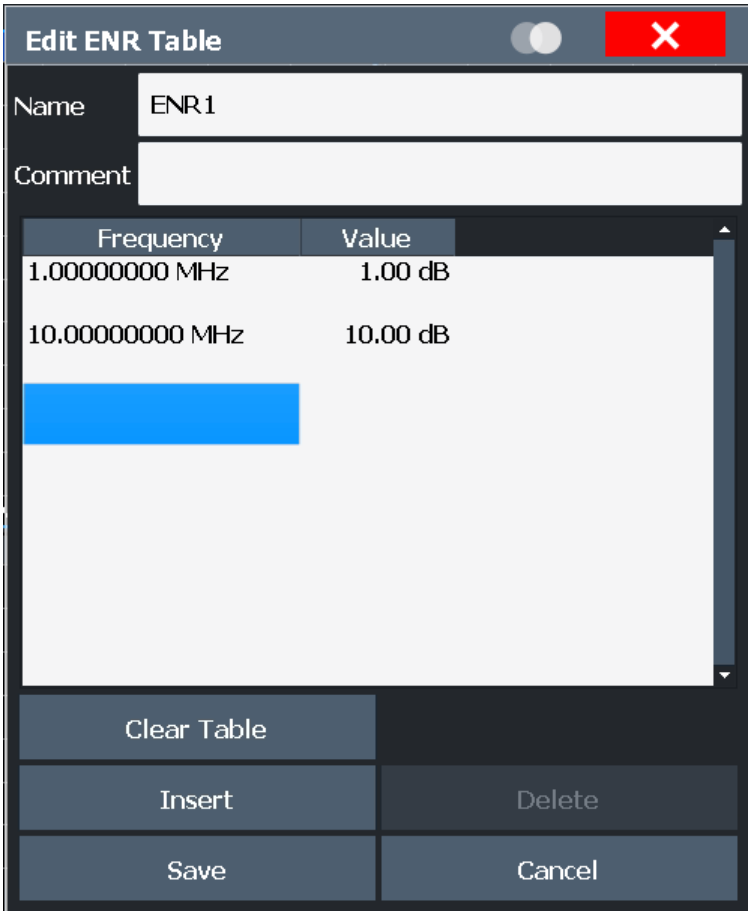
Copy To
Opens the Edit Table dialog box to modify the selected table and save it under a new name.

Import / Export Table
Opens a dialog box to select a table to import or export.

Smart noise source tables can be exported, but not re-imported. Tables for smart noise sources are always loaded directly from the SNS itself. However, you can edit and use the SNS tables for other noise sources, such as noise diodes.

Edit Table
Defines the noise source characteristics or the loss characteristics of additional measurement equipment.

The noise source and loss tables are made up of up to 10001 data points. A data point consists of a frequency and its corresponding ENR, temperature or loss value. The ENR and temperature values must be supplied by the manufacturer of the noise source or resistor. The loss characteristics of measurement equipment must also be supplied by the manufacturer.



"Name" Name of the ENR, temperature or loss table.

"Comment" Comment for the ENR, temperature or loss table.

"Frequency" Frequency of a particular ENR, temperature or loss value.

"Value"	ENR value or loss in dB. For a resistor, the characteristics of the resistor are defined by the "noise temperatures" T_{hot} and T_{cold} instead of a single value. The unit in that case is Kelvin (degrees).
"Clear Table"	Deletes the contents of the table (frequencies and values) or the loss table.
"Insert"	Inserts a new data point above the selected one.
"Delete"	Deletes the selected data point.
"Save"	Saves the able.
"Cancel"	Exits the "Edit Table" dialog box and returns to the result diagram.

Remote command:
Edit ENR table: `[SENSe:]CORRection:ENR[:MEASurement]:TABLe[:DATA]` on page 117
Edit temperature table: `[SENSe:]CORRection:ENR[:MEASurement]:TABLe:TEMPerature[:DATA]` on page 118
Edit input loss table: `[SENSe:]CORRection:LOSS:INPut:TABLe[:DATA]` on page 125
Edit output loss table: `[SENSe:]CORRection:LOSS:OUTPut:TABLe[:DATA]` on page 127

5.5 Configuring additional loss

These settings configure the loss characteristics of additional equipment in the test setup, such as cables or attenuators at the DUT input or output. The characteristics of such equipment must be supplied by the manufacturer.

Note that loss is only considered during the measurement and not during calibration because the noise source is connected directly to the analyzer input.

Treatment of losses in resistor noise sources

For resistor noise sources, it is not possible to change the loss characteristics.

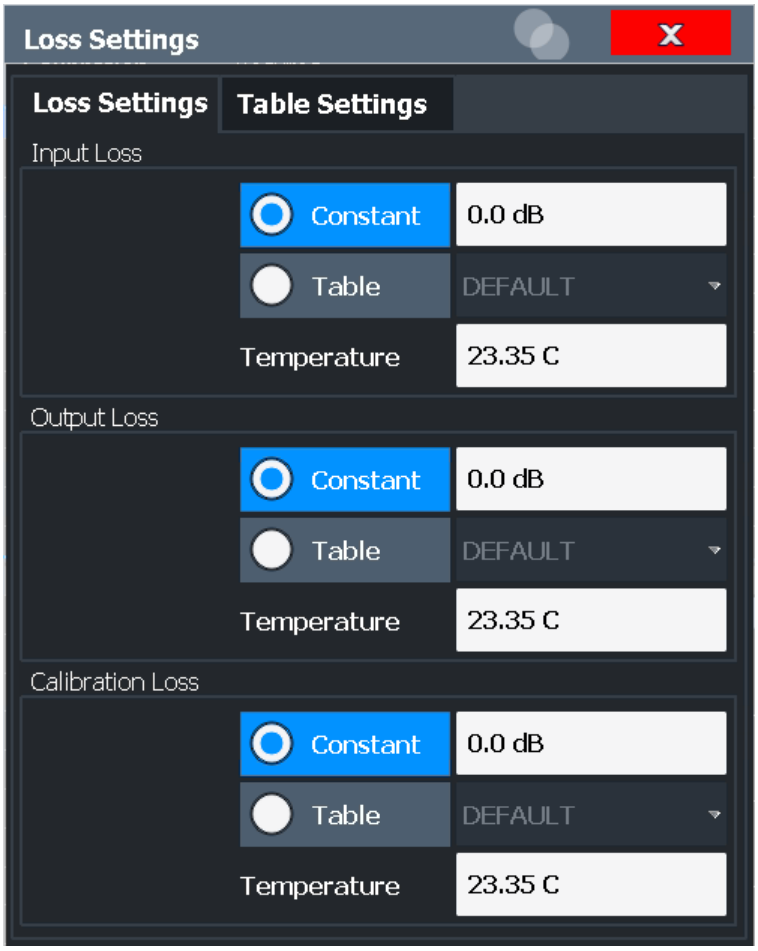
When you change back to using a diode as a noise source, the previous loss settings are **not** restored. In that case, store loss settings in a loss table for later use.

- Defining loss 59
- Using a loss table 62

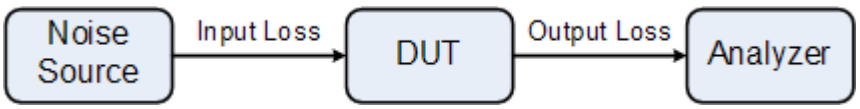
5.5.1 Defining loss

Access: "Overview" > "Loss Input" / "Loss Output" > "Loss Settings"

The "Loss Settings" tab in the "Loss Settings" dialog box contains settings to define the loss characteristics of miscellaneous equipment in the test setup.



You can define the loss characteristics of the signal path to the DUT input and the signal path from the DUT output to the analyzer.



Furthermore, you can define the loss characteristics of the signal path from the noise source directly to the analyzer for the calibration measurement.

Input Loss....60
Output Loss....61
Calibration Loss....61

Input Loss
Defines losses between the noise source and the DUT input.

The input loss is the sum of all losses caused by the measurement equipment. The loss can be constant or based on a loss table.

If the loss is constant, the same loss is used for all frequencies in the frequency table. If you have selected a constant loss, you can also define its value in the input field next to the radio button.

If the loss is based on a table, the loss values are interpolated to the measurement frequencies. You can select a table from the dropdown menu next to the radio button, if it is active. For more information on loss tables, see Chapter 5.5.2, "Using a loss table", on page 62.

The specified temperature at the time of measurement can be considered in the loss calculation.

Remote command:
Loss mode:
`[SENSe:]CORRection:LOSS:INPut:MODE` on page 124
Constant loss:
`[SENSe:]CORRection:LOSS:INPut:SPOT` on page 124
Select loss table:
`[SENSe:]CORRection:LOSS:INPut:TABLe:SELect` on page 125
Temperature:
`[SENSe:]CORRection:LOSS:INPut:TEMPerature` on page 126

Output Loss
Selects the loss between the DUT output and the RF input of the analyzer.

The output loss is the sum of all losses caused by the measurement equipment (e.g. connectors, cables or attenuators). The loss can be constant or be based on a loss table.

If the loss is constant, the same loss is used for all frequencies in the frequency table. If you have selected a constant loss, you can also define its value in the input field next to the radio button.

If the loss is based on a table, the loss values are interpolated to the measurement frequencies. You can select a table from the dropdown menu next to the radio button, if it is active. For more information on loss tables, see Chapter 5.5.2, "Using a loss table", on page 62.

The current temperature at the time of measurement can be considered in the loss calculation.

Remote command:
Loss mode:
`[SENSe:]CORRection:LOSS:OUTPut:MODE` on page 126
Constant loss:
`[SENSe:]CORRection:LOSS:OUTPut:SPOT` on page 126
Select loss table:
`[SENSe:]CORRection:LOSS:OUTPut:TABLe:SELect` on page 127
Temperature:
`[SENSe:]CORRection:LOSS:OUTPut:TEMPerature` on page 128

Calibration Loss
Selects the loss between the noise source and the RF input of the analyzer for the calibration measurement.

The loss is the sum of all losses caused by the measurement equipment (e.g. connectors, cables or attenuators). The loss can be constant or be based on a loss table.

If the loss is constant, the same loss is used for all frequencies in the frequency table. If you have selected a constant loss, you can also define its value in the input field next to the radio button.

If the loss is based on a table, the loss values are interpolated to the measurement frequencies. You can select a table from the dropdown menu next to the radio button, if it is active. For more information on loss tables, see Chapter 5.5.2, "Using a loss table", on page 62.

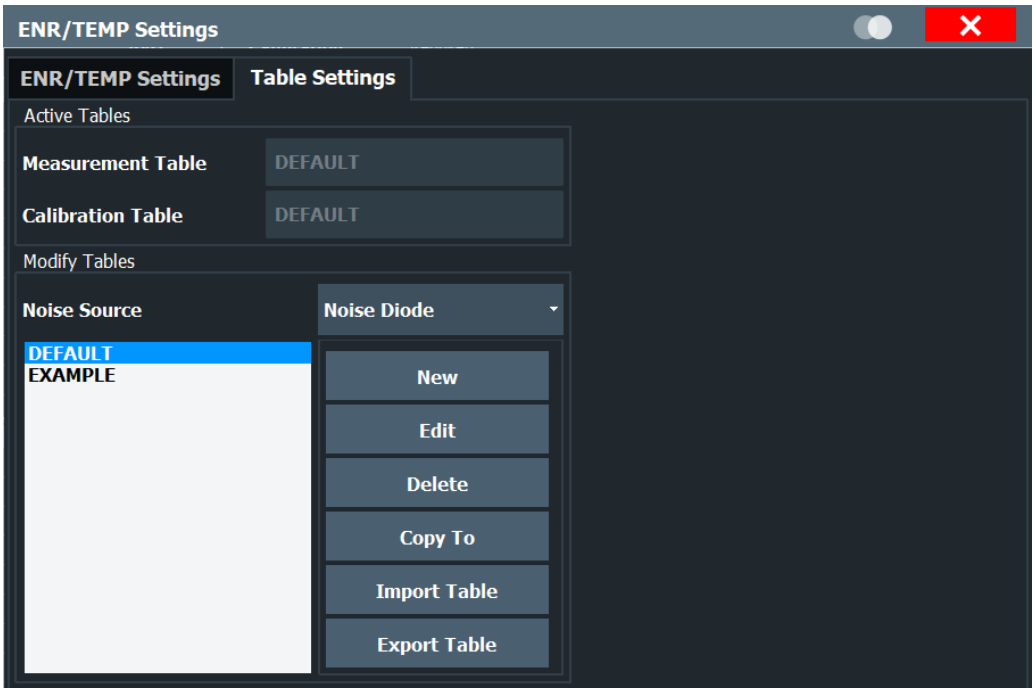
The current temperature at the time of measurement can be considered in the loss calculation.

Remote command:
Loss mode:
`[SENSe:]CORRection:LOSS:CALibration:MODE` on page 122
Constant loss:
`[SENSe:]CORRection:LOSS:CALibration:SPOT` on page 122
Select loss table:
`[SENSe:]CORRection:LOSS:CALibration:TABLe:SELect` on page 123
Temperature:
`[SENSe:]CORRection:LOSS:CALibration:TEMPerature` on page 124

5.5.2 Using a loss table

Access: "Overview" > "Loss Input" / "Loss Output" > "Table Settings"

The "Table Settings" tab in the "Loss Settings" dialog box contains the functionality to create and edit loss tables.



Loss tables contain the loss characteristics of additional frequency-dependent equipment in the test setup. If you are using a loss table, the loss values can be different on

each frequency that is measured. If the table does not contain a loss for one of the measurement frequencies, the application interpolates between values.

The "Table Settings" tab contains a list of loss tables currently available on the R&S ZNL. It shows the table currently selected in the "Loss Settings" tab.

In addition, the tab contains functionality to create new tables and modify existing ones.

New....63
Edit....63
Delete....63
Copy To....63
Import / Export Table....64

New
Opens the Edit Table dialog box to create a new loss table.

The contents of the dialog box are empty.

Remote command:
Create input loss table:
`[SENSe:]CORRection:LOSS:INPut:TABLe[:DATA]` on page 125
Create output loss table:
`[SENSe:]CORRection:LOSS:OUTPut:TABLe[:DATA]` on page 127
Create calibration loss table:
`[SENSe:]CORRection:LOSS:CALibration:TABLe[:DATA]` on page 123

Edit
Opens the Edit Table dialog box to modify the selected table.

Remote command:
Edit input loss table:
`[SENSe:]CORRection:LOSS:INPut:TABLe[:DATA]` on page 125
Edit output loss table:
`[SENSe:]CORRection:LOSS:OUTPut:TABLe[:DATA]` on page 127
Edit calibration loss table:
`[SENSe:]CORRection:LOSS:CALibration:TABLe[:DATA]` on page 123

Delete
Deletes the selected table.

Remote command:
Delete input loss table:
`[SENSe:]CORRection:LOSS:INPut:TABLe:DELete` on page 125
Delete output loss table:
`[SENSe:]CORRection:LOSS:OUTPut:TABLe:DELete` on page 127
Delete calibration loss table:
`[SENSe:]CORRection:LOSS:CALibration:TABLe:DELete` on page 122

Copy To
Opens the Edit Table dialog box to modify the selected table and save it under a new name.

Import / Export Table
Opens a dialog box to select a loss table to import or export.

An import copies the loss table into the default loss table directory. The file extension can be `*.loss` or `*.s2p`. In case the file extension is `*.s2p`, the S21 vector is parsed out of the `*.s2p` file. The magnitude of this vector is written to a file with ending `*.loss` into the default loss directory. This file then can be used like conventional loss files.

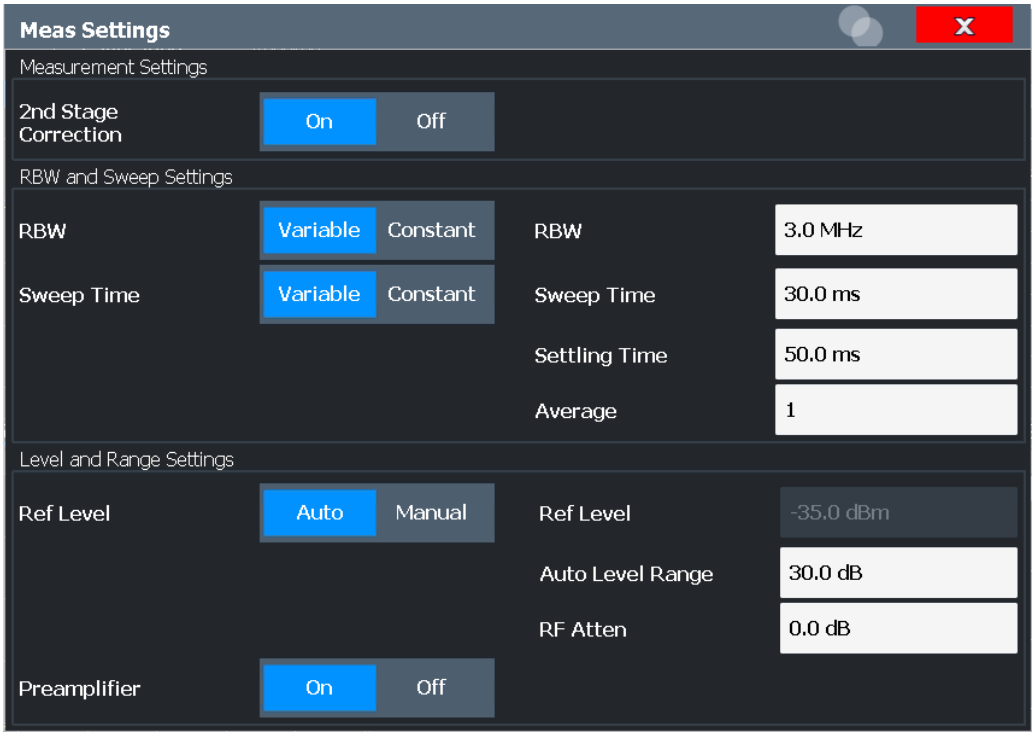
An export copies the table to a location outside the default loss table directory, e.g. a memory stick. The file extension will be `*.loss`.

5.6 Configuring the analyzer

Access: "Overview" > "Spectrum Analyzer"

Or: [MEAS CONFIG] > "Meas Settings"

The measurement settings include parameters related to the second stage correction measurement.



2nd Stage Correction 65
Resolution Bandwidth (RBW) 65
Sweep Time 65
Settling Time 66
Average 66

Ref Level....66
Auto Level Range....67
RF Attenuation....67

2nd Stage Correction
Turns 2nd stage correction on and off.

If enabled, the application uses the calibration data to compensate for the inherent noise of the analyzer when calculating the measurement results.

If disabled, the application does not correct the measurement results, even if a valid calibration has been performed. Note that correction data is not deleted if you turn off the 2nd stage correction.

For more information, see Chapter 4.5, "Calibration (2nd stage correction)", on page 32.

Remote command:
State: `[SENSe:]CORRection[:STATe]` on page 130
Calibration measurement selection: `[SENSe:]CONFigure:CORRection` on page 129

Resolution Bandwidth (RBW)
Defines the resolution bandwidth for the measurement.

For more information on the resolution bandwidth, see Chapter 4.7, "Separating signals by selecting an appropriate resolution bandwidth", on page 36.

"Constant" Uses a constant RBW for the entire measurement span

"Variable" Uses a variable RBW, depending on the current frequency of the sweep point, as defined in the frequency table (see Chapter 5.2.3, "Using a frequency table", on page 47);
In the channel bar, the bandwidth and sweep time range of the variable values is indicated.

Remote command:
`[SENSe:]BANDwidth:RESolution:AUTO` on page 129
`[SENSe:]BANDwidth[:RESolution]` on page 128

Sweep Time
Defines the sweep time for the measurement.

The sweep time is the time it takes the analyzer to perform a measurement at one measurement frequency.

Note that "noise figure" measurements perform two measurements during one sweep. One with the noise source turned on, one with the noise source turned off.

Frequency tables allow you to define a variable RBW and sweep time, depending on the current frequency of the sweep point (see "Variable RBW and sweep time for low-frequency measurements" on page 37 and Chapter 5.2.3, "Using a frequency table", on page 47).

"Constant" Uses a constant sweep time for the entire measurement span

"Variable" Uses a variable sweep time, depending on the current frequency of the sweep point, as defined in the frequency table (see Chapter 5.2.3, "Using a frequency table", on page 47);
In the channel bar, the bandwidth and sweep time range of the variable values is indicated.

Remote command:
`[SENSe:]SWEep:TIME:AUTO` on page 131
`[SENSe:]SWEep:TIME` on page 131

Settling Time
Defines the settling time of the DUT and the noise source.

Most noise sources need a certain amount of time to settle after you turn them on. Low-frequency DUTs can require a certain time until their coupling capacitors have been charged or discharged. Both are defined as the settling time. For details on the settling time, refer to the datasheet of the noise source.

Remote command:
`SYSTem:CONFigure:DUT:STIMe` on page 133

Average
Defines the number of measurements that are used to average the results.

The more measurements you include in the averaging, the more accurate and stable the results are. However, accuracy and stability come at the price of measurement speed.

Remote command:
`[SENSe:]SWEep:COUNt` on page 131

Ref Level
Turns automatic determination of the reference level on and off.

The reference level is the power level the R&S ZNL expects at the RF input. Keep in mind that the noise signal has a high crest factor. To avoid an instrument overload, set the reference level to the peak envelope power of the noise signal, not to the mean power.

Set the reference level to approximately 5 dB to 15 dB above the noise display that occurs with the DUT connected and the noise source activated.

To get the best dynamic range, set the reference level as low as possible. At the same time, make sure that the maximum signal level does not exceed the reference level. If it does, it can overload the RF and IF stages of the analyzer, regardless of the signal power. Measurement results can deteriorate.

Note that the signal level at the A/D converter can be stronger than the level the R&S ZNL displays because the resolution bandwidths are implemented digitally after the A/D converter.

If automatic detection of the reference level is on, the application performs a measurement to determine the ideal reference level. The time of this measurement depends on the state of the "2nd Stage Correction".

- "2nd Stage Correction" is enabled

The application determines the reference level before the calibration starts. The reference level is based on several test measurements on the start frequency. For more information, see "Auto Level Range" on page 67.

- "2nd Stage Correction" is disabled
  The application determines the reference level before the measurement begins. The reference level is based on the measurement of the first frequency that is measured. After this measurement is done, the application resumes the measurement.

If manual selection of the reference level is on, you can define the reference level in the corresponding input field.

Note: Reference level. Even for DUTs with a high-ripple frequency response it can be useful to define the reference level manually. Determining the reference level automatically does not always result in optimal settings.

Remote command:
Manual reference level:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel` on page 132
Automatic reference level:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel:AUTO` on page 132

Auto Level Range
Defines the maximum expected "gain" of the DUT.

The application uses the auto level range to determine the reference level automatically if the 2nd stage correction is on.

Make sure the range does not exceed the actual "gain" of the DUT by more than 10 dB.

Remote command:
`SYSTem:CONFigure:DUT:GAIN` on page 133

RF Attenuation
Defines the RF attenuation of the analyzer.

The attenuation is applied to the signal at the RF input.

Attenuation affects the quality of the "noise figure" measurement results. For a low "noise figure" of the analyzer (and thus more accurate measurement results), keep the attenuation as low as possible. No attenuation is best. However, some high-power DUTs require attenuation to avoid an overload of the analyzer. An attenuation of 10 dB provides a better input VSWR of the analyzer, but results in a deteriorating "noise figure".

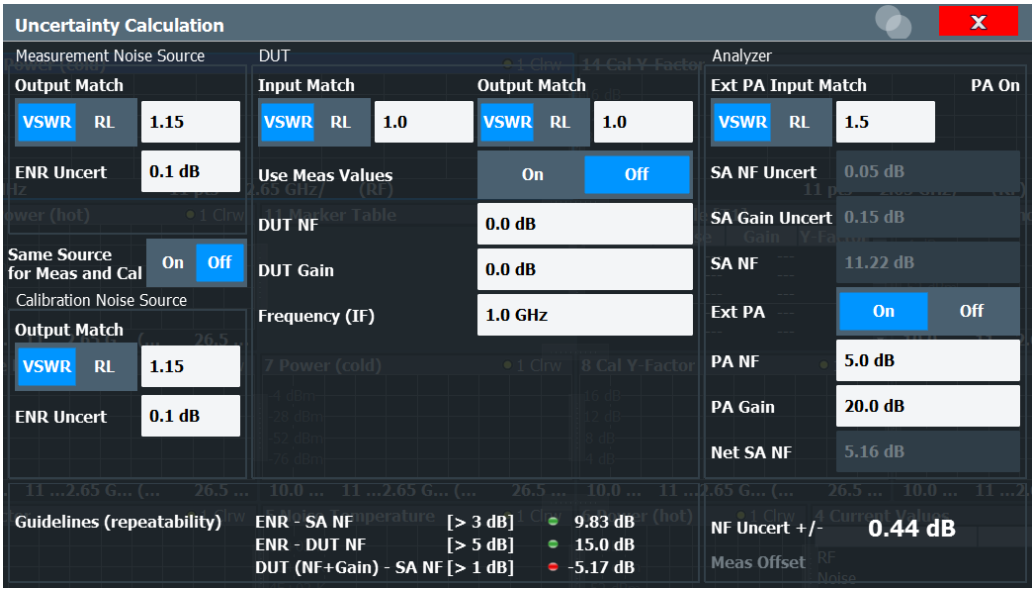
Remote command:
`INPut<ip>:ATTenuation` on page 132

5.7 Using the uncertainty calculator

Access: [MEAS CONFIG] > "Uncertainty Calculation"

"Noise figure" measurements are subject to uncertainty. The "noise figure" measurement is meaningless if the measurement uncertainty is too large. Knowing the uncertainty of the "noise figure" measurement adds value especially when comparing measurement results.

Note that the "noise figure" uncertainty is not calculated for frequencies above 67 GHz because input VSWR values are not specified.



Uncertainty values and systematic error recognition

Note that the uncertainty calculation only takes systematic measurement inaccuracies into account.

The most significant inaccuracies are:

- Uncertainties of the noise source and the analyzer
- Input and output matching
- "Noise figure" and "gain" of the DUT
- "Noise figure" of the analyzer

The accuracy of the measurement can also be affected by insufficient repeatability during calibration or measurement.

The repeatability is mainly affected by:

- Signal-to-noise ratio during calibration and measurement
- Measurement time (if it is too short)
- Environmental conditions (e.g. a change in the temperature between measurements)
- Mechanical stability of the test setup

For more background information on "noise figure" measurement uncertainty, refer to the application note "The "Y-Factor" Technique for "Noise Figure" Measurement" available for download on the Rohde & Schwarz homepage (http://www.rohde-

schwarz.com/en/applications/the-y-factor-technique-for-noise-figure-measurements-application-note_56280-15484.html).

In addition to the parameters described here, the application also considers several parameters from the general measurement configuration when calculating the uncertainty.

- Measurement mode
- 2nd Stage Correction
  If 2nd stage correction is on, but no calibration data is available, uncertainty is calculated without the 2nd stage correction data.
- RF Attenuation
- Temperature
- ENR values

5.7.1 Configuring noise source characteristics

Access: [MEAS CONFIG] > "Uncertainty Calculation"

The Uncertainty Calculator supports individual characteristics for a noise source used during calibration and the measurement.

If you are using a Common ENR, the application assumes that the Output Match and ENR Uncert(ainty) are the same during calibration and measurement. Only the "Measurement Noise Source" parameters are displayed.

If you are using a different noise source during calibration and measurement, the Uncertainty Calculator adds an Output Match and ENR Uncert(ainty) required for uncertainty calculation during calibration.

Note that you have to turn off the Common Noise Source if you have to define the values of the noise source used during calibration.

Common Source for Meas and Cal....69
Use SNS Values....70
Output Match....70
ENR Uncert(ainty)....70
Temperature Uncert(ainty)....70

Common Source for Meas and Cal
Controls the way the application calculates the uncertainty for the noise source.

Turn on the switch when you use the same noise source during calibration and measurement. Only one set of fields to define the noise source characteristics is available. The application calculates the uncertainty according to the values you have entered in there.

Turn the switch off when you use different noise sources during calibration and measurement. The application shows an additional set of fields to define the noise source characteristics. The uncertainty calculation also includes these values.

The switch is available if you have turned on Common Noise Source.

Remote command:
CALCulate<n>:UNCertainty:COMMon on page 134

Use SNS Values
If enabled, the values from the uncertainty table provided by the (most recently) connected smart noise source are used.

Output Match
Defines the output match of the noise source you are using.

You can define the output match either as the VSWR or as the return loss (RL).

Refer to the datasheet of the noise source for these values.

If a smart noise source is used, the VSWR / RL values defined in the SNS table are used.

Remote command:
CALCulate<n>:UNCertainty:MATCh:SOURce:CALibration:RL on page 140
CALCulate<n>:UNCertainty:MATCh:SOURce:RL on page 141
CALCulate<n>:UNCertainty:MATCh:SOURce:CALibration[:VSWR] on page 140
CALCulate<n>:UNCertainty:MATCh:SOURce:CALibration:RL on page 140

ENR Uncert(ainty)
Defines the uncertainty of the excess noise ratio of the noise source you are using.

Refer to the datasheet of the noise source for this value.

Available for noise sources with diode characteristics.

If a smart noise source is used, the ENR uncertainty values defined in the SNS table are used.

Remote command:
CALCulate<n>:UNCertainty:ENR:UNCertainty on page 137
CALCulate<n>:UNCertainty:ENR:CALibration:UNCertainty on page 136

Temperature Uncert(ainty)
Defines the uncertainty of the hot and cold temperatures of the noise source you are using.

Refer to the datasheet of the noise source for these values.

Available for resistor noise sources.

Remote command:
CALCulate<n>:UNCertainty:ENR:UNCertainty:COLD on page 137
CALCulate<n>:UNCertainty:ENR:CALibration:UNCertainty:HOT on page 137
CALCulate<n>:UNCertainty:ENR:CALibration:UNCertainty:COLD on page 136
CALCulate<n>:UNCertainty:ENR:CALibration:UNCertainty:HOT on page 137

5.7.2 Configuring DUT characteristics

Access: [MEAS CONFIG] > "Uncertainty Calculation"

Input / Output Match....71
Use Measurement Values....71

Input / Output Match
Defines the match at the DUT input and output.

You can define the match either as the VSWR or as the return loss (RL). If you define the VSWR or the return loss, the application automatically calculates the other.

If these values are not defined in the DUT datasheet, determine these values, for example, with a network analyzer.

Remote command:
`CALCulate<n>:UNCertainty:MATCh:DUT:IN[:VSWR]` on page 138
`CALCulate<n>:UNCertainty:MATCh:DUT:IN:RL` on page 138
`CALCulate<n>:UNCertainty:MATCh:DUT:OUT[:VSWR]` on page 139
`CALCulate<n>:UNCertainty:MATCh:DUT:OUT:RL` on page 139

Use Measurement Values
Turns automatic determination of the DUT characteristics used for the uncertainty calculation on and off.

If on, the application calculates the uncertainty with the DUT characteristics ("noise figure", "gain" and frequency) resulting from the "noise figure" measurement. For this method, the application calculates the uncertainty for each measurement point (or frequency) based on the "noise figure" and "gain" results of the last measurement.

If you have selected automatic determination of the DUT characteristics, the application does not show a result in the "NF Uncertainty +/-" field in the dialog box. Instead, to view the uncertainty at all measurement points, use the "Result Table".

If off, define the "gain", "noise figure" and frequency of the DUT manually for a single frequency. With this manual determination of the DUT characteristics, the application only calculates the uncertainty for that frequency and shows the result in the "NF Uncertainty +/-" field in the dialog box.

- "Noise Figure" of the DUT
- "Gain" of the DUT
- Frequency of the DUT

Remote command:
Control automatic DUT characteristics determination:
`CALCulate<n>:UNCertainty[:RESult]?` on page 142
Manual definition of DUT characteristics:
`CALCulate<n>:UNCertainty:DATA:NOISe` on page 135
`CALCulate<n>:UNCertainty:DATA:GAIN` on page 135
`CALCulate<n>:UNCertainty:DATA:FREQuency` on page 134

5.7.3 Configuring analyzer characteristics

Access: [MEAS CONFIG] > "Uncertainty Calculation"

For the analyzer characteristics, the application always uses the data specified in the datasheet of the R&S ZNL model you are using. Thus, it is not possible to change or adjust the analyzer characteristics in any way. The uncertainty calculation takes several analyzer characteristics into account, of which the following are shown as read-only fields in the user interface.

- **SA Input Match:** Input match (VSWR or return loss) of the analyzer
- **SA NF Uncert:** "Noise figure" uncertainty of the analyzer
- **SA "Gain" Uncert:** "Gain" uncertainty of the analyzer
- **SA NF:** "Noise figure" of the analyzer

However, if you are using an external preamplifier in the test setup, you have to specify its characteristics to get a valid uncertainty result.

Remote commands:

`CALCulate<n>:UNCertainty:SANalyzer:GAIN:UNCertainty?` on page 143

`CALCulate<n>:UNCertainty:SANalyzer:NOISe:UNCertainty?` on page 143

External Preamplifier (Ext PA)....72
└ Preamplifier noise figure (PA NF)....72
└ Preamplifier Gain (PA Gain)....72
└ Net spectrum analyzer noise figure (Net SA NF)....72

External Preamplifier (Ext PA)
If enabled, the application automatically calculates and updates the analyzer characteristics based on the characteristics of the external preamplifier defined here.

Refer to the datasheet of the preamplifier you are using for the values you have to enter.

Remote command:
`CALCulate<n>:UNCertainty:PREamp:STATe` on page 142

Preamplifier noise figure (PA NF) ← External Preamplifier (Ext PA)
Defines the "noise figure" of the preamplifier.

Remote command:
`CALCulate<n>:UNCertainty:PREamp:NOISe` on page 142

Preamplifier Gain (PA Gain) ← External Preamplifier (Ext PA)
Defines the "gain" of the preamplifier.

Remote command:
`CALCulate<n>:UNCertainty:PREamp:GAIN` on page 141

Net spectrum analyzer noise figure (Net SA NF) ← External Preamplifier (Ext PA)
Shows the "noise figure" of the analyzer.

If you are using an external preamplifier, the application calculates the "noise figure" of the analyzer including the "noise figure" of the preamplifier and shows the result here.

If you do not use an external preamplifier, this value is the same as the "noise figure" of the analyzer shown in the "SA NF" field.

5.7.4 Guidelines and results

Access: [MEAS CONFIG] > "Uncertainty Calculation"

The lower part of the dialog box contains measurement guidelines that provide information on the quality of measurement and the actual "noise figure" uncertainty.

Guidelines

The guidelines are an indicator of the quality of the measurement and an indicator the repeatability of the measurement.

The three guidelines are:

- Make sure that the "noise figure" of the DUT and the "gain" of the DUT is greater than the "noise figure" of the analyzer plus 1 dB.
- Make sure that the ENR of the noise source is greater than the "noise figure" of the DUT plus 5 dB.
- Make sure that the ENR of the noise source is greater than the "noise figure" of the analyzer plus 3 dB.

A short form of these guidelines is indicated in the "Uncertainty Calculation" dialog box. The dialog box also indicates if the guidelines have been met or not by a colored dot.

- Green light : guideline condition met.
- Yellow light : guideline condition not met, but within 1 dB of being met.
- Red light : guideline condition not met.

Note that the guidelines have no effect on the actual uncertainty that has been calculated and that they are only considered for measurements with 2nd Stage Correction.

Uncertainty

The "Uncertainty" result is shown only if you define the "noise figure" and "gain" characteristics of the DUT manually on a single frequency. In that case, the uncertainty shown in the "Uncertainty Calculation" dialog box is valid only for the DUT frequency you have defined.

The "Measurement Offset" evaluates the internal noise of the R&S ZNL that is added to the "noise figure" results. The measurement offset result is displayed when 2nd stage correction is turned off. When you turn on 2nd stage correction, the internal noise is automatically removed from the uncertainty results, so the measurement offset is not shown.

If you are using the "noise figure" and "gain" that has been determined during a measurement, the uncertainty is displayed only in the result table.

For more information, see "Use Measurement Values" on page 71.

SCPI command:

CALCulate<n>:UNCertainty[:RESult]? on page 142

5.8 Performing measurements

Access: [SWEEP]

Access (calibration): "Overview" > "Calibrate"

This chapter contains all functionality necessary to control and perform "noise figure" measurements.

Continuous Sweep / Run Cont 74
Single Sweep / Run Single 74
Calibrate 75
Sweep Time 75
Meas Mode (Auto Manual) 75

Continuous Sweep / Run Cont
Initiates a measurement and repeats it continuously until stopped. If necessary, the application automatically determines the reference level before starting the actual measurement.

While the measurement is running, the "Continuous Sweep" softkey and the [RUN CONT] key are highlighted. The running measurement can be aborted by selecting the highlighted softkey or key again. The results are not deleted until a new measurement is started.

Note: Sequencer. If the Sequencer is active, the "Continuous Sweep" softkey only controls the sweep mode for the currently selected channel setup. However, the sweep mode only takes effect the next time the Sequencer activates that channel setup, and only for a channel-defined sequence. In this case, a channel setup in continuous sweep mode is swept repeatedly.
Furthermore, the [RUN CONT] key controls the Sequencer, not individual sweeps. [RUN CONT] starts the Sequencer in continuous mode.

For details on the Sequencer, see the R&S ZNL User Manual.

Remote command:
INITiate<n>:CONTinuous on page 144

Single Sweep / Run Single
Initiates a single measurement. The measurement is finished after all frequencies in the frequency list have been measured. If necessary, the application automatically determines the reference level before starting the actual measurement.

After triggering, initiates a single measurement. The measurement is finished after all frequencies in the frequency list have been measured. If necessary, the application automatically determines the reference level before starting the actual measurement.

While the measurement is running, the "Single Sweep" softkey and the [RUN SINGLE] key are highlighted. The running measurement can be aborted by selecting the highlighted softkey or key again.

Note: Sequencer. If the Sequencer is active, the "Single Sweep" softkey only controls the sweep mode for the currently selected channel setup. However, the sweep mode only takes effect the next time the Sequencer activates that channel setup, and only for a channel-defined sequence. In this case, the Sequencer sweeps a channel setup in single sweep mode only once.
Furthermore, the [RUN SINGLE] key controls the Sequencer, not individual sweeps. [RUN SINGLE] starts the Sequencer in single mode.

If the Sequencer is off, only the evaluation for the currently displayed channel setup is updated.

For details on the Sequencer, see the R&S ZNL User Manual.

Remote command:
`INITiate<n>[:IMMediate]` on page 145

Calibrate
Initiates a calibration measurement.

For interpolation purposes, R&S ZNL-K30 will internally add addiitonal measurement points at the band switching frequencies. This may increase the time needed to complete the calibration.

For more information see Chapter 4.5, "Calibration (2nd stage correction)", on page 32.

Remote command:
`INITiate<n>[:IMMediate]` on page 145
when `[SENSe:]CONFigure:CORRection` is on.

Sweep Time
Defines the sweep time.

For more information see "Sweep Time" on page 65.

Meas Mode (Auto Manual)
Selects the measurement mode for the hot and cold power measurements.

For more information about the measurement modes see Chapter 4.2, "Measurement modes", on page 27.

In manual measurement mode, the application opens a dialog box when you start a measurement. For more information about its contents see "Performing a manual measurement" on page 27.

Remote command:
`[SENSe:]CONFigure:CONTrol` on page 146
`[SENSe:]CONFigure:MEASurement` on page 146

5.9 Configuring inputs and outputs of the R&S ZNL

The only input setting available for the R&S FPL1 Noise Figure measurements application on the R&S ZNL is Chapter 5.9.1, "Impedance", on page 76.

In addition, the optional independent CW source is supported. See the R&S ZNL Spectrum Mode user manual.

- Impedance 76

5.9.1 Impedance

Access: [MEAS] > "Input Source Config"

Impedance
For some measurements, the reference impedance for the measured levels of the R&S ZNL can be set to 50 Ω or 75 Ω.

Select 75 Ω if the 50 Ω input impedance is transformed to a higher impedance using a 75 Ω adapter of the RAZ type. (That corresponds to 25Ω in series to the input impedance of the instrument.) The correction value in this case is 1.76 dB = 10 log (75Ω/50Ω).

Remote command:
`INPut<ip>:IMPedance` on page 148

6 Analysis

This chapter contains all settings and parameters that the application provides to analyze and evaluate measurement results.

- Configuring the display....77
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6.1 Configuring the display

Access: [MEAS CONFIG] > "Result Config"

Display configuration settings configure the way the results are displayed in the diagram.

The contents depend on whether you want to configure a graphical result display or a numerical result display.

Specifics for

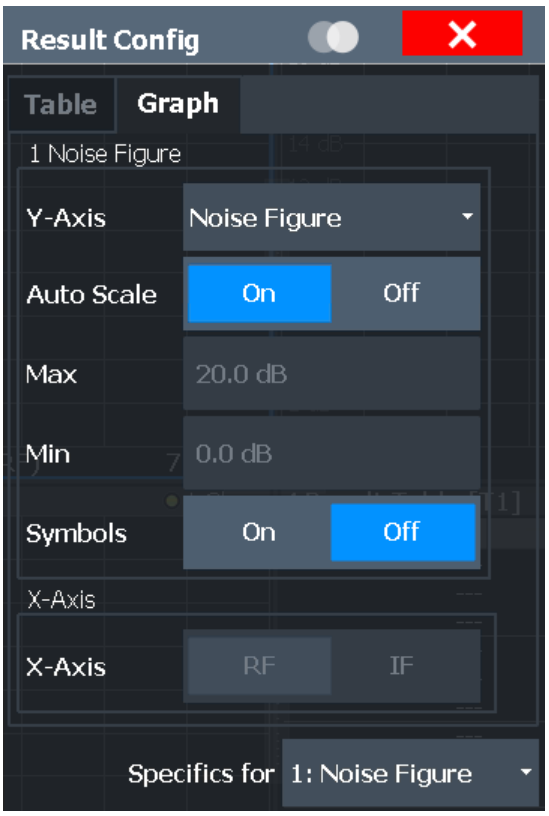
The settings you make apply to the results you have selected in the "Specifics for" dropdown menu. If more than one window is active, "Specifics for" also puts the focus on the corresponding window.

- Configuring graphical results....77
- Configuring numerical results....79

6.1.1 Configuring graphical results

Access: [MEAS CONFIG] > "Result Config" > "Graph"

When configuring graphical results, the dialog box contains functionality to scale and set up the diagram axes.



Y-Axis 78
Auto Scale / Min / Max 78
Symbols 79
X-Axis 79

Y-Axis
Selects the result display and thus the scaling of the vertical axis.

For more information, see Chapter 3, "Measurements and result displays", on page 15.

Auto Scale / Min / Max
Turns automatic scaling of the vertical axis on and off.

If on, the application optimizes the scaling of the vertical axis after each measurement for ideal viewing of the results.

If off, you can define the scaling manually. The "Min" and "Max" input fields become available. These two input fields define the values at the top and bottom of the vertical axis.

Remote command:
Automatic scaling:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO` on page 151
Manual minimum value:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:BOTTom` on page 150
Manual maximum value
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:TOP` on page 151

Symbols
Turns symbols that represent a measurement point on the trace on and off.

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:SYMBols` on page 149

X-Axis
Selects the frequency data that is displayed on the x-axis.

For measurements on frequency converting DUTs with a variable intermediate frequency, you can display either the RF frequency or the IF frequency.

Note that a change of the x-axis scale applies to all result displays, and also determines which value is output for trace export.

The "Frequency Axis" scale is also available via the [FREQ] key.

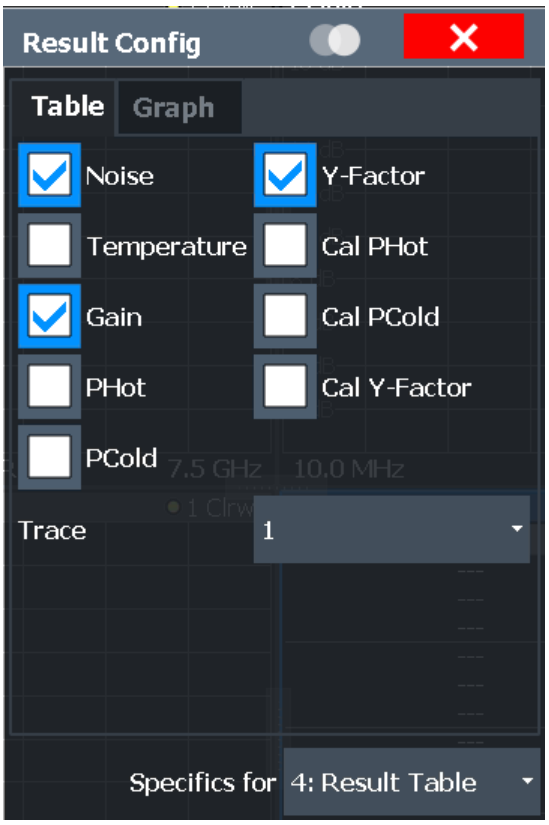
Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:X[:SCALe]` on page 149

6.1.2 Configuring numerical results

When configuring numerical results, the dialog box selects the type of results you want to display in the result table. The results in the table are based on a particular trace that you can select in the corresponding input field.

You can add an aspect of the measurement by placing a checkmark in front of the corresponding result on and remove it by removing the checkmark.

For more information on each result, see Chapter 3, "Measurements and result displays", on page 15.



Remote command:

`DISPlay[:WINDow<n>]:TABLe:ITEM` on page 148

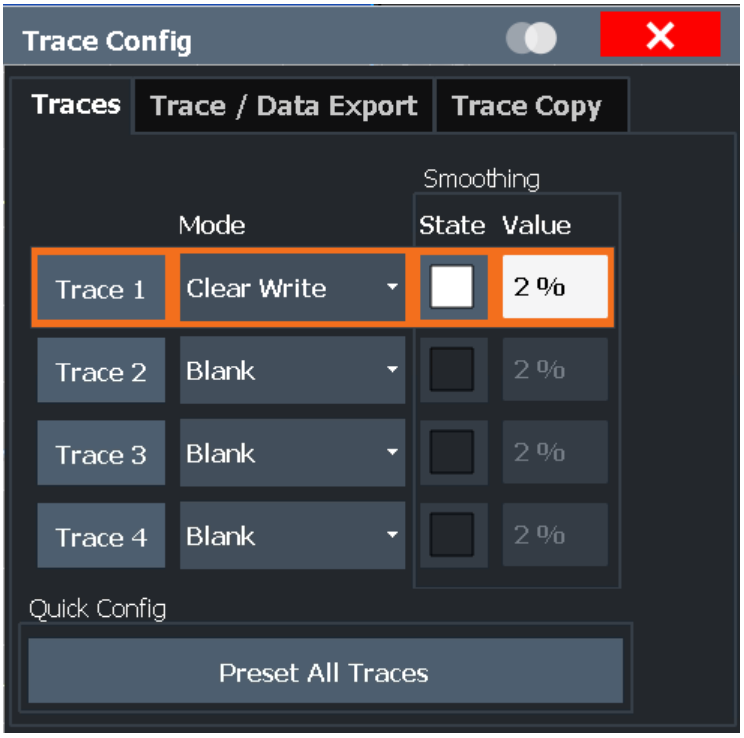
6.2 Working with traces

Access (trace configuration): [TRACE] > "Trace Config" > "Traces"

Access (trace export): [TRACE] > "Trace Config" > "Trace / Data Export"

Access (copy trace): [TRACE] > "Trace Config" > "Trace Copy"

A trace is the graphical representation of a set of measurement results in a diagram. Each measurement window that contains graphical results supports up to four individual traces. Each trace has a different color. Trace settings determine how the measured data is analyzed and displayed on the screen. The trace information, including a color map and trace mode is summarized in the diagram header.



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Smoothing 82
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Trace Export 82
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└ Include Instrument & Measurement Settings 82
└ Trace to Export 82
└ Decimal Separator 82
└ Export Trace to ASCII File 82
Copy Trace 83

Traces

The "Trace 1 to 4" softkeys open the "Traces" tab of the "Trace Configuration" dialog box.

The "Traces" tab contains functionality to configure a trace.

"Trace Selection" — The "Trace 1" to "Trace 4" buttons select a trace. If a trace is selected, it is highlighted orange.
Note that you cannot select a trace if its trace mode is "Blank".

"Trace Mode" — Selects the trace mode for the corresponding trace.
For more information, see Chapter 4, "Measurement basics", on page 24.

Remote command:
Trace mode:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE` on page 152

Smoothing
If enabled, the trace is smoothed by the specified value (between 1 % and 50 %). The smoothing value is defined as a percentage of the display width. The larger the smoothing value, the greater the smoothing effect.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing[:STATe]` on page 153
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing:APERture` on page 153

Preset Traces
Restores the default configuration for all traces in a window.

Trace Export
The "Trace Export" tab contains functionality to export trace data.

Export all Traces and all Table Results ← Trace Export
Selects all displayed traces and result tables (e.g. "Result Summary", marker table etc.) in the current application for export to an ASCII file.

Alternatively, you can select one specific trace only for export (see Trace to Export).

The results are output in the same order as they are displayed on the screen: window by window, trace by trace, and table row by table row.

Remote command:
`FORMat:DEXPort:TRACes` on page 155

Include Instrument & Measurement Settings ← Trace Export
Includes additional instrument and measurement settings in the header of the export file for result data.

Remote command:
`FORMat:DEXPort:HEADer` on page 155

Trace to Export ← Trace Export
Defines an individual trace to be exported to a file.

This setting is not available if Export all Traces and all Table Results is selected.

Decimal Separator ← Trace Export
Defines the decimal separator for floating-point numerals for the data export/import files. Evaluation programs require different separators in different languages.

Remote command:
`FORMat:DEXPort:DSEParator` on page 154

Export Trace to ASCII File ← Trace Export
Opens a file selection dialog box and saves the selected trace in ASCII format (`.dat`) to the specified file and directory.

The results are output in the same order as they are displayed on the screen: window by window, trace by trace, and table row by table row.

The column headers are provided as the first row. Whether the frequency value represents the RF or IF frequency depends on the X-Axis setting.

Remote command:
MMEMory:STORe<n>:TRACe on page 155

Copy Trace
Access: "Overview" > "Analysis" > "Traces" > "Copy Trace"

Or: [TRACE] > "Copy Trace"

Copies trace data to another trace.

The first group of buttons (labeled "Trace 1" to "Trace 4") selects the source trace. The second group of buttons (labeled "Copy to Trace 1" to "Copy to Trace 4") selects the destination.

Remote command:
TRACe<n>:COPY on page 156

6.3 Using markers

Markers help you to read out measurement results for particular frequencies or mark a particular point on a trace. The "noise figure" application features four markers. Markers in the "noise figure" application are linked. If you use more than one measurement window and activate a marker in one window, it also appears in all other measurement windows on the same horizontal position.

- Marker configuration 83
- Marker positioning 86

6.3.1 Marker configuration

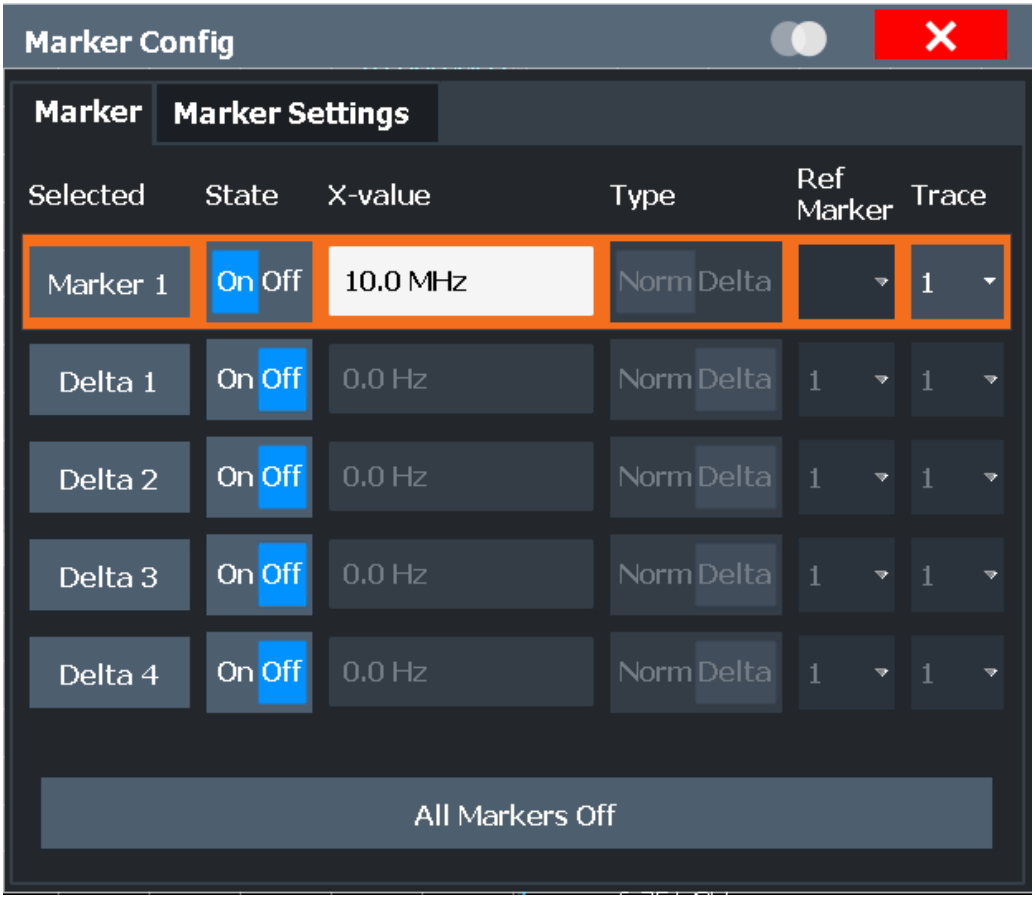
Access (marker configuration): [MKR] > "Marker Config" > "Marker"

Access (marker settings): [MKR] > "Marker Config" > "Marker Settings"

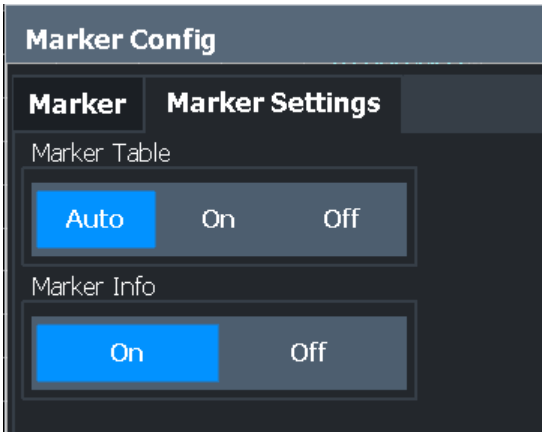
The "Marker Configuration" dialog box and the "Marker" menu contain all functionality necessary to control markers.

The "Marker Configuration" dialog box consists of two tabs.

The "Markers" tab contains functionality to define characteristics for each marker.



The "Marker Settings" tab contains general marker functionality.



Marker (1...4) 85
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Marker (1...4)
Selects or turns the corresponding marker on and off.

Turning on a marker also opens an input field to define the horizontal position of the marker.

By default, the first marker you turn on is a normal marker, all others are delta markers.

Marker Type
Toggles the marker type.

The type for marker 1 is always "Normal", the type for delta marker 1 is always "Delta " . These types cannot be changed.

Note: If normal marker 1 is the active marker, switching the "Mkr Type" activates an additional delta marker 1. For any other marker, switching the marker type does not activate an additional marker, it only switches the type of the selected marker.

"Normal"	A normal marker indicates the absolute value at the defined position in the diagram.
"Delta "	A delta marker defines the value of the marker relative to the specified reference marker (marker 1 by default).

Remote command:
`CALCulate<n>:MARKer<m>[:STATe]` on page 166
`CALCulate<n>:DELTamarker<m>[:STATe]` on page 169

Marker to Trace
Opens an input field to assign the marker to a particular trace if you are using more than one trace.

All Markers Off
Deactivates all markers in one step.

Remote command:
`CALCulate<n>:MARKer<m>:AOFF` on page 165

Marker Config
Opens the "Marker Configuration" dialog box.

The "Marker Configuration" dialog box contains all marker functions necessary to set up the four markers supported by the application.

- Selected
  Highlights the currently selected marker.
- State
  Turns a marker on and off.
- X-value
  Defines the marker position on the horizontal axis.
- Type
  Selects the marker type. For more information see " Marker Type " on page 85.
- Trace
  Selects the trace the marker is positioned on.

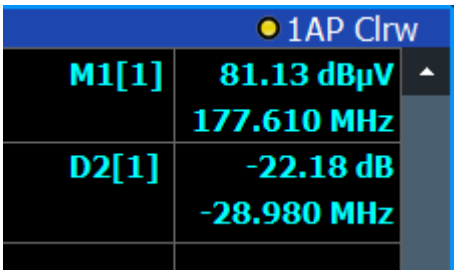
Marker Table Display
Defines how the marker information is displayed.

"On" Displays the marker information in a table in a separate area beneath the diagram.

"Off" No separate marker table is displayed.
If Marker Info is active, the marker information is displayed within the diagram area.

Remote command:
`DISPlay[:WINDow<n>]:MTABle` on page 171

Marker Info
Turns the marker information displayed in the diagram on and off.



Remote command:
`DISPlay[:WINDow<n>]:MINFo[:STATe]` on page 171

6.3.2 Marker positioning

If you are using more than one measurement window, the application performs the peak search in the currently selected measurement window. The currently selected measurement window has a blue border. Because the markers are linked in the "noise figure" application, the frequency position of the marker in the other window is updated accordingly, even if it means that the marker is on a peak in one window only.

Select Marker <x> 86
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Search Minimum 87
Search Next Minimum 87
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Select Marker <x>
Opens a dialog box to select and activate or deactivate one or more markers.

The number in the softkey label (**<x>**) shows the number of the currently selected marker.

Remote command:
Marker selected via suffix <m> in remote commands.

Peak Search
Sets the selected marker/delta marker to the maximum of the trace. If no marker is active, marker 1 is activated.

Remote command:
`CALCulate<n>:MARKer<m>:MAXimum[:PEAK]` on page 172
`CALCulate<n>:DELTamarker<m>:MAXimum[:PEAK]` on page 174

Search Next Peak
Sets the selected marker/delta marker to the next (lower) maximum of the assigned trace. If no marker is active, marker 1 is activated.

Remote command:
`CALCulate<n>:MARKer<m>:MAXimum:NEXT` on page 172
`CALCulate<n>:MARKer<m>:MAXimum:RIGHt` on page 172
`CALCulate<n>:MARKer<m>:MAXimum:LEFT` on page 172
`CALCulate<n>:DELTamarker<m>:MAXimum:NEXT` on page 174
`CALCulate<n>:DELTamarker<m>:MAXimum:RIGHt` on page 175
`CALCulate<n>:DELTamarker<m>:MAXimum:LEFT` on page 174

Search Minimum
Sets the selected marker/delta marker to the minimum of the trace. If no marker is active, marker 1 is activated.

Remote command:
`CALCulate<n>:MARKer<m>:MINimum[:PEAK]` on page 173
`CALCulate<n>:DELTamarker<m>:MINimum[:PEAK]` on page 175

Search Next Minimum
Sets the selected marker/delta marker to the next (higher) minimum of the selected trace. If no marker is active, marker 1 is activated.

Remote command:
CALCulate<n>:MARKer<m>:MINimum:NEXT on page 173
CALCulate<n>:MARKer<m>:MINimum:LEFT on page 173
CALCulate<n>:MARKer<m>:MINimum:RIGHt on page 173
CALCulate<n>:DELTamarker<m>:MINimum:NEXT on page 175
CALCulate<n>:DELTamarker<m>:MINimum:LEFT on page 175
CALCulate<n>:DELTamarker<m>:MINimum:RIGHt on page 176

Marker to Single Frequency
Starts a single frequency measurement on the current marker position.

When you use this function, the application changes the tuning mode and automatically adjusts the single frequency to that of the current marker position.

For more information see Chapter 4.1.3, "Single frequency measurements", on page 26.

7 Remote control commands for noise figure measurements

The following remote control commands are required to configure and perform "noise figure" measurements in a remote environment. The R&S ZNL must already be set up for remote operation in a network as described in the base unit manual.

Common functionality

Note that basic tasks that are also performed in the base unit in the same way are not described here. For a description of such tasks, see the R&S ZNL User Manual.

In particular, this includes:

- Managing Settings and Results, i.e. storing and loading settings and result data.
- Basic instrument configuration, e.g. checking the system configuration, customizing the screen layout, or configuring networks and remote operation.
- Using the common status registers (specific status registers for Pulse measurements are not used).

Channel Setup-specific commands

Apart from a few general commands on the R&S ZNL, most commands refer to the currently active channel setup. Thus, always remember to activate a "Noise Figure" channel setup before starting a remote program for a "noise figure" measurement.

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7.1 Common suffixes

In the R&S FPL1 Noise Figure measurements application, the following common suffixes are used in remote commands:

Table 7-1: Common suffixes used in remote commands in the R&S FPL1 Noise Figure measurements application

Suffix	Value range	Description
<m>	1 to 4	Marker
<n>	1 to 16	Window (**in the currently selected channel setup**)
<t>	1 to 4	Trace
	1 to 8	Limit line

7.2 Introduction

Commands are program messages that a controller (e.g. a PC) sends to the instrument or software. They operate its functions ('setting commands' or 'events') and request information ('query commands'). Some commands can only be used in one way, others work in two ways (setting and query). If not indicated otherwise, the commands can be used for settings and queries.

The syntax of a SCPI command consists of a header and, usually, one or more parameters. To use a command as a query, you have to append a question mark after the last header element, even if the command contains a parameter.

A header contains one or more keywords, separated by a colon. Header and parameters are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). If there is more than one parameter for a command, they are separated by a comma from one another.

Only the most important characteristics that you need to know when working with SCPI commands are described here. For a more complete description, refer to the user manual of the R&S ZNL.

Remote command examples

Note that some remote command examples mentioned in this general introduction are possibly not supported by this particular application.

7.2.1 Conventions used in descriptions

The following conventions are used in the remote command descriptions:

- **Command usage**
  If not specified otherwise, commands can be used both for setting and for querying parameters.

If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.

- **Parameter usage**
  If not specified otherwise, a parameter can be used to set a value and it is the result of a query.
  Parameters required only for setting are indicated as **Setting parameters**.
  Parameters required only to refine a query are indicated as **Query parameters**.
  Parameters that are only returned as the result of a query are indicated as **Return values**.
- **Conformity**
  Commands that are taken from the SCPI standard are indicated as **SCPI confirmed**. All commands used by the R&S ZNL follow the SCPI syntax rules.
- **Asynchronous commands**
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an **Asynchronous command**.
- **Reset values (*RST)**
  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as ***RST** values, if available.
- **Default unit**
  The default unit is used for numeric values if no other unit is provided with the parameter.

7.2.2 Long and short form

The keywords have a long and a short form. You can use either the long or the short form, but no other abbreviations of the keywords.

The short form is emphasized in uppercase letters. Note however, that this emphasis only serves the purpose to distinguish the short from the long form in the manual. For the instrument, the case does not matter.

Example:

`SENSe:FREQuency:CENTer` is the same as `SENS:FREQ:CENT`.

7.2.3 Numeric suffixes

Some keywords have a numeric suffix if the command can be applied to multiple instances of an object. In that case, the suffix selects a particular instance (e.g. a measurement window).

Numeric suffixes are indicated by angular brackets (<n>) next to the keyword.

If you do not quote a suffix for keywords that support one, a 1 is assumed.

Example:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe` enables the zoom in a particular measurement window, selected by the suffix at `WINDow`.

`DISPlay:WINDow4:ZOOM:STATe ON` refers to window 4.

7.2.4 Optional keywords

Some keywords are optional and are only part of the syntax because of SCPI compliance. You can include them in the header or not.

If an optional keyword has a numeric suffix and you need to use the suffix, you have to include the optional keyword. Otherwise, the suffix of the missing keyword is assumed to be the value 1.

Optional keywords are emphasized with square brackets.

Example:

Without a numeric suffix in the optional keyword:

`[SENSe:]FREQuency:CENTer` is the same as `FREQuency:CENTer`

With a numeric suffix in the optional keyword:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe`

`DISPlay:ZOOM:STATe ON` enables the zoom in window 1 (no suffix).

`DISPlay:WINDow4:ZOOM:STATe ON` enables the zoom in window 4.

7.2.5 Alternative keywords

A vertical stroke indicates alternatives for a specific keyword. You can use both keywords to the same effect.

Example:

`[SENSe:]BANDwidth|BWIDth[:RESolution]`

In the short form without optional keywords, `BAND 1MHZ` would have the same effect as `BWID 1MHZ`.

7.2.6 SCPI parameters

Many commands feature one or more parameters.

If a command supports more than one parameter, they are separated by a comma.

Example:

`LAYout:ADD:WINDow Spectrum,LEFT,MTABle`

Parameters can have different forms of values.

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- Boolean 94
- Character data 94
- Character strings 94
- Block data 94

7.2.6.1 Numeric values

Numeric values can be entered in any form, i.e. with sign, decimal point or exponent. For physical quantities, you can also add the unit. If the unit is missing, the command uses the basic unit.

Example:

With unit: `SENSe:FREQuency:CENTer 1GHZ`

Without unit: `SENSe:FREQuency:CENTer 1E9` would also set a frequency of 1 GHz.

Values exceeding the resolution of the instrument are rounded up or down.

If the number you have entered is not supported (e.g. for discrete steps), the command returns an error.

Instead of a number, you can also set numeric values with a text parameter in special cases.

- MIN/MAX
  Defines the minimum or maximum numeric value that is supported.
- DEF
  Defines the default value.
- UP/DOWN
  Increases or decreases the numeric value by one step. The step size depends on the setting. Sometimes, you can customize the step size with a corresponding command.

Querying numeric values

When you query numeric values, the system returns a number. For physical quantities, it applies the basic unit (e.g. Hz for frequencies). The number of digits after the decimal point depends on the type of numeric value.

Example:

Setting: `SENSe:FREQuency:CENTer 1GHZ`

Query: `SENSe:FREQuency:CENTer?` would return `1E9`

Sometimes, numeric values are returned as text.

- INF/NINF
  Infinity or negative infinity. Represents the numeric values 9.9E37 or -9.9E37.
- NAN

Not a number. Represents the numeric value 9.91E37. NAN is returned if errors occur.

7.2.6.2 Boolean

Boolean parameters represent two states. The "on" state (logically true) is represented by "ON" or the numeric value 1. The "off" state (logically untrue) is represented by "OFF" or the numeric value 0.

Querying Boolean parameters

When you query Boolean parameters, the system returns either the value 1 ("ON") or the value 0 ("OFF").

Example:

Setting: `DISPlay:WINDow:ZOOM:STATe ON`

Query: `DISPlay:WINDow:ZOOM:STATe?` would return `1`

7.2.6.3 Character data

Character data follows the syntactic rules of keywords. You can enter text using a short or a long form. For more information, see Chapter 7.2.2, "Long and short form", on page 91.

Querying text parameters

When you query text parameters, the system returns its short form.

Example:

Setting: `SENSe:BANDwidth:RESolution:TYPE NORMal`

Query: `SENSe:BANDwidth:RESolution:TYPE?` would return `NORM`

7.2.6.4 Character strings

Strings are alphanumeric characters. They have to be in straight quotation marks. You can use a single quotation mark (') or a double quotation mark (").

Example:

```
INSTRument:DELete 'Spectrum'
```

7.2.6.5 Block data

Block data is a format which is suitable for the transmission of large amounts of data.

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. The data bytes follow. During the transmission of these data bytes, all end or other control signs are ignored until

all bytes are transmitted. #0 specifies a data block of indefinite length. The use of the indefinite format requires an NL^END message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

7.3 Controlling the noise figure measurement channel

The following commands are necessary to control the measurement channel.

INSTrument:CREate:DUPLicate 95
INSTrument:CREate[:NEW] 95
INSTrument:CREate:REPLace 95
INSTrument:DELete 96
INSTrument:LIST? 96
INSTrument:REName 97
INSTrument[:SELect] 97
SYSTem:PRESet:CHANnel[:EXEC] 98

INSTrument:CREate:DUPLicate

This command duplicates the currently selected channel setup, i.e creates a new channel setup of the same type and with the identical measurement settings. The name of the new channel setup is the same as the copied channel setup, extended by a consecutive number (e.g. "IQAnalyzer" -> "IQAnalyzer 2").

The channel setup to be duplicated must be selected first using the INST:SEL command.

Usage: Event

INSTrument:CREate[:NEW] <ChannelType>, <ChannelName>

This command adds a measurement channel. You can configure up to 10 measurement channels at the same time (depending on available memory).

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types, see INSTrument:LIST? on page 96.

<ChannelName> String containing the name of the channel.
Note that you cannot assign an existing channel name to a new channel. If you do, an error occurs.

Example: INST:CRE SAN, 'Spectrum 2'
Adds a spectrum display named "Spectrum 2".

INSTrument:CREate:REPLace <ChannelName1>,<ChannelType>,<ChannelName2>

This command replaces a channel setup with another one.

Setting parameters:

<ChannelName1> String containing the name of the channel setup you want to replace.

<ChannelType> Channel type of the new channel setup.
For a list of available channel setup types, see `INSTrument:LIST?` on page 96.

<ChannelName2> String containing the name of the new channel setup.
Note: If the specified name for a new channel setup already exists, the default name, extended by a sequential number, is used for the new channel setup (see `INSTrument:LIST?` on page 96).
Channel names can have a maximum of 31 characters, and must be compatible with the Windows conventions for file names. In particular, they must not contain special characters such as ":", "*", "?".

Usage: Setting only

INSTrument:DELete <ChannelName>

This command deletes a channel setup.

Setting parameters:

<ChannelName> String containing the name of the channel setup you want to delete.
A channel setup must exist to delete it.

Usage: Setting only

INSTrument:LIST?

This command queries all active channel setups. The query is useful to obtain the names of the existing channel setups, which are required to replace or delete the channel setups.

Return values:

<ChannelType>, <ChannelName> For each channel setup, the command returns the channel setup type and channel setup name (see tables below).
Tip: to change the channel setup name, use the `INSTrument:REName` command.

Example:
```
INST:LIST?
```
Result for 3 channel setups:
```
'ADEM','Analog Demod','IQ','IQ Analyzer','IQ','IQ Analyzer2'
```

Usage: Query only

Table 7-2: Available channel setup types and default channel setup names

Application	<ChannelType> Parameter	Default Channel Setup Name*)
Spectrum	SANALYZER	Spectrum
AM/FM/PM Modulation Analysis	ADEM	Analog Demod
I/Q Analyzer	IQ	IQ Analyzer
Noise Figure Measurements	NOISE	Noise
Vector Signal Analysis (VSA)	DDEM	VSA
Network analysis	Vna	VNA
Note: the default channel setup name is also listed in the table. If the specified name for a new channel setup already exists, the default name, extended by a sequential number, is used for the new channel setup.		

INSTrument:REName <ChannelName1>, <ChannelName2>

This command renames a channel setup.

Setting parameters:

<ChannelName1> String containing the name of the channel setup you want to rename.

<ChannelName2> String containing the new channel setup name.
Note that you cannot assign an existing channel setup name to a new channel setup. If you do, an error occurs.
Channel names can have a maximum of 31 characters, and must be compatible with the Windows conventions for file names. In particular, they must not contain special characters such as ":", "*", "?".

Usage: Setting only

INSTrument[:SELect] <ChannelType> | <ChannelName>

This command activates a new channel setup with the defined channel setup type, or selects an existing channel setup with the specified name.

Also see

- `INSTrument:CREate[:NEW]` on page 95

Parameters:

<ChannelType> Channel type of the new channel setup.
For a list of available channel setup types see `INSTrument:LIST?` on page 96.

<ChannelName> String containing the name of the channel setup.

Example: `INST IQ`
`INST 'MyIQSpectrum'`
Selects the channel setup named 'MyIQSpectrum' (for example before executing further commands for that channel setup).

SYSTem:PRESet:CHANnel[:EXEC]

This command restores the default instrument settings in the current channel setup.

Use `INST:SEL` to select the channel setup.

Example: `INST:SEL 'Spectrum2'`
Selects the channel setup for "Spectrum2".
`SYST:PRES:CHAN:EXEC`
Restores the factory default settings to the "Spectrum2"channel setup.

Usage: Event

Manual operation: See "Preset Channel Setup" on page 43

7.4 Working with windows in the display

The following commands are required to change the evaluation type and rearrange the screen layout for a channel setup as you do using the SmartGrid in manual operation. Since the available evaluation types depend on the selected application, some parameters for the following commands also depend on the selected channel setup.

Note that the suffix <n> always refers to the window *in the currently selected channel setup*.

LAYout:ADD[:WINDow]?..... 98
LAYout:CATalog[:WINDow]?..... 100
LAYout:IDENtify[:WINDow]?..... 100
LAYout:REMove[:WINDow]..... 101
LAYout:REPLace[:WINDow]..... 101
LAYout:SPLitter..... 101
LAYout:WINDow<n>:ADD?..... 103
LAYout:WINDow<n>:IDENtify?..... 103
LAYout:WINDow<n>:REMove..... 104
LAYout:WINDow<n>:REPLace..... 104

LAYout:ADD[:WINDow]? <WindowName>, <Direction>, <WindowType>

This command adds a window to the display in the active channel setup.

This command is always used as a query so that you immediately obtain the name of the new window as a result.

To replace an existing window, use the `LAYout:REPLace[:WINDow]` command.

Query parameters:

<WindowName> String containing the name of the existing window the new window is inserted next to.
By default, the name of a window is the same as its index. To determine the name and index of all active windows, use the `LAYout:CATalog[:WINDow]?` query.

<Direction> LEFT | RIGHt | ABOVe | BELow
Direction the new window is added relative to the existing window.

<WindowType> text value
Type of result display (evaluation method) you want to add.
See the table below for available parameter values.

Return values:

<NewWindowName> When adding a new window, the command returns its name (by default the same as its number) as a result.

Example:
```
LAY:ADD? '1',LEFT,MTAB
```
Result:
```
'2'
```
Adds a new window named '2' with a marker table to the left of window 1.

Usage: Query only

Manual operation:
See "Noise Figure" on page 16
See "Gain" on page 17
See "Noise Temperature" on page 17
See "Y-Factor" on page 18
See "ENR Measured" on page 19
See "Power (Hot)" on page 20
See "Power (Cold)" on page 20
See "Cal Y-Factor" on page 21
See "Cal Power (Hot)" on page 21
See "Cal Power (Cold)" on page 22
See "Result Table" on page 22
See "Marker Table" on page 23

Table 7-3: <WindowType> parameter values for Noise Figure application

Parameter value	Window type
CPCold	Cal Power (Cold)
CPHot	Cal Power (Hot)
CYFactor	"Cal Y-Factor"
ENR	ENR Measured
GAIN	"Gain" result display
MTABle	Marker table
NOISe	"Noise figure" result display

Parameter value	Window type
PCOLd	Power cold result display
PHOT	Power hot result display
RESults	Result table
TEMPerature	"Noise temperature" result display
YFACtor	"Y-Factor" result display

LAYout:CATalog[:WINDow]?

This command queries the name and index of all active windows in the active channel setup from top left to bottom right. The result is a comma-separated list of values for each window, with the syntax:

<WindowName_1>,<WindowIndex_1>..<WindowName_n>,<WindowIndex_n>

Return values:

<WindowName> string

Name of the window.
In the default state, the name of the window is its index.

<WindowIndex> **numeric value**
Index of the window.

Example: `LAY:CAT?`
Result:
`'2',2,'1',1`
Two windows are displayed, named '2' (at the top or left), and '1' (at the bottom or right).

Usage: Query only

LAYout:IDENtify[:WINDow]? <WindowName>

This command queries the **index** of a particular display window in the active channel setup.

Note: to query the **name** of a particular window, use the `LAYout:WINDow<n>:IDENtify?` query.

Query parameters:

<WindowName> String containing the name of a window.

Return values:

<WindowIndex> Index number of the window.

Example: `LAY:IDEN:WIND? '2'`
Queries the index of the result display named '2'.
Response:
`2`

Usage: Query only

LAYout:REMove[:WINDow] <WindowName>

This command removes a window from the display in the active channel.

Setting parameters:

<WindowName> String containing the name of the window. In the default state, the name of the window is its index.

Example: `LAY:REM '2'`
Removes the result display in the window named '2'.

Usage: Setting only

LAYout:REPLace[:WINDow] <WindowName>,<WindowType>

This command replaces the window type (for example from "Diagram" to "Result Summary") of an already existing window in the active channel setup while keeping its position, index and window name.

To add a new window, use the `LAYout:ADD[:WINDow]?` command.

Setting parameters:

<WindowName> String containing the name of the existing window.
By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active channel setup, use the `LAYout:CATalog[:WINDow]?` query.

<WindowType> Type of result display you want to use in the existing window.
See `LAYout:ADD[:WINDow]?` on page 98 for a list of available window types.

Example: `LAY:REPL:WIND '1',MTAB`
Replaces the result display in window 1 with a marker table.

Usage: Setting only

LAYout:SPLitter <Index1>, <Index2>, <Position>

This command changes the position of a splitter and thus controls the size of the windows on each side of the splitter.

Note that windows must have a certain minimum size. If the position you define conflicts with the minimum size of any of the affected windows, the command does not work, but does not return an error.

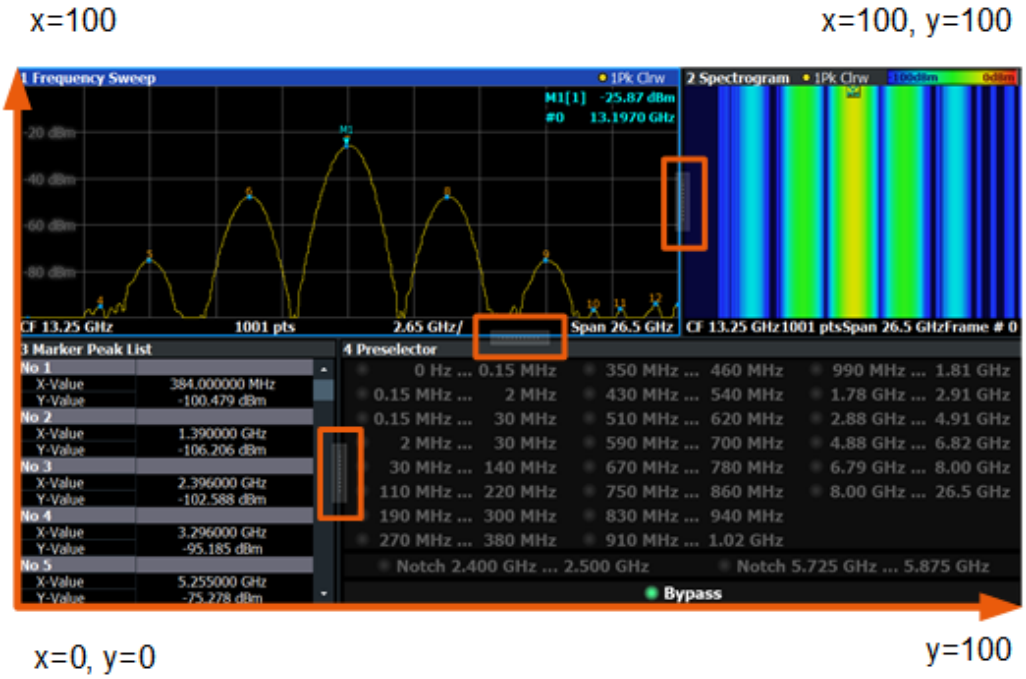

Figure 7-1: SmartGrid coordinates for remote control of the splitters

Setting parameters:

<Index1> The index of one window the splitter controls.

<Index2> The index of a window on the other side of the splitter.

<Position> New vertical or horizontal position of the splitter as a fraction of the screen area (without channel and status bar and softkey menu).
The point of origin (x = 0, y = 0) is in the lower left corner of the screen. The end point (x = 100, y = 100) is in the upper right corner of the screen. (See Figure 7-1.)
The direction in which the splitter is moved depends on the screen layout. If the windows are positioned horizontally, the splitter also moves horizontally. If the windows are positioned vertically, the splitter also moves vertically.

Range: 0 to 100

Example: `LAY:SPL 1,3,50`
Moves the splitter between window 1 ('Frequency Sweep') and 3 ('"Marker Table"') to the center (50%) of the screen, i.e. in the figure above, to the left.

Example: LAY:SPL 1,4,70
Moves the splitter between window 1 ('Frequency Sweep') and 3 ('"Marker Peak List"') towards the top (70%) of the screen.
The following commands have the exact same effect, as any combination of windows above and below the splitter moves the splitter vertically.
LAY:SPL 3,2,70
LAY:SPL 4,1,70
LAY:SPL 2,1,70

Usage: Setting only

LAYout:WINDow<n>:ADD? <Direction>,<WindowType>

This command adds a measurement window to the display. Note that with this command, the suffix <n> determines the existing window next to which the new window is added. Unlike LAYout:ADD[:WINDow]?, for which the existing window is defined by a parameter.

To replace an existing window, use the LAYout:WINDow<n>:REPLace command.

This command is always used as a query so that you immediately obtain the name of the new window as a result.

Suffix:
<n> Window

Query parameters:
<Direction> LEFT | RIGHt | ABOVe | BELow

<WindowType> Type of measurement window you want to add.
See LAYout:ADD[:WINDow]? on page 98 for a list of available window types.

Return values:
<NewWindowName> When adding a new window, the command returns its name (by default the same as its number) as a result.

Example: LAY:WIND1:ADD? LEFT,MTAB
Result:
'2'
Adds a new window named '2' with a marker table to the left of window 1.

Usage: Query only

LAYout:WINDow<n>:IDENtify?

This command queries the **name** of a particular display window (indicated by the <n> suffix) in the active channel setup.

Note: to query the **index** of a particular window, use the LAYout:IDENtify[:WINDow]? command.

Suffix:
<n> Window

Return values:
<WindowName> String containing the name of a window.
In the default state, the name of the window is its index.

Example: `LAY:WIND2:IDEN?`
Queries the name of the result display in window 2.
Response:
`'2'`

Usage: Query only

LAYout:WINDow<n>:REMove

This command removes the window specified by the suffix <n> from the display in the active channel setup.

The result of this command is identical to the `LAYout:REMove[:WINDow]` command.

Suffix:
<n> Window

Example: `LAY:WIND2:REM`
Removes the result display in window 2.

Usage: Event

LAYout:WINDow<n>:REPLace <WindowType>

This command changes the window type of an existing window (specified by the suffix <n>) in the active channel setup.

The effect of this command is identical to the `LAYout:REPLace[:WINDow]` command.

To add a new window, use the `LAYout:WINDow<n>:ADD?` command.

Suffix:
<n> Window

Setting parameters:
<WindowType> Type of measurement window you want to replace another one with.
See `LAYout:ADD[:WINDow]?` on page 98 for a list of available window types.

Example: `LAY:WIND2:REPL MTAB`
Replaces the result display in window 2 with a marker table.

Usage: Setting only

7.5 General window commands

The following commands are required to configure general window layout, independent of the application.

DISPlay[:WINDow<n>]:SIZE 105

DISPlay[:WINDow<n>]:SIZE <Size>

This command maximizes the size of the selected result display window *temporarily*. To change the size of several windows on the screen permanently, use the `LAY:SPL` command (see `LAYout:SPLitter` on page 101).

Suffix:
<n> Window

Parameters:
<Size>

LARGe
Maximizes the selected window to full screen.
Other windows are still active in the background.

SMALl
Reduces the size of the selected window to its original size.
If more than one measurement window was displayed originally, these are visible again.

*RST: SMALl

Example:
```
DISP:WIND2:SIZE LARG
```

7.6 Retrieving measurement results

The following commands are necessary to query measurement results.

TRACe<n>[:DATA]? 105

TRACe<n>[:DATA]? <Trace>[, <Result>]

This command queries the "noise figure" measurement results.

Suffix:
<n> 1..n
Window

Query parameters:
<Trace> TRACe1 | TRACe2 | TRACe3 | TRACe4

Selects the trace to be read out.

TRACE1

TRACE2

TRACE3

TRACE4

<Result> NOISe | GAIN | TEMPerature | YFACtor | ENR | PHOT | PCOLd | CYFactor | CPHot | CPCold | NUNCertainty

Selects the result display to be read out.

ALL
Queries all available results for the measurement.

CPCold
Queries calibration power (cold) results.

CPHot
Queries calibration power (hot) results.

CYFactor
Queries calibration "y-factor" results.

ENR
Queries ENR measured results.

GAIN
Queries "gain" results.

NOISe
Queries "noise figure" results.

NUNCertainty
Queries "noise figure" uncertainty results.

PCOLd
Queries power (cold) results.

PHOT
Queries power (hot) results.

TEMPerature
Queries "noise temperature" results.

X
Queries the x values (frequency).

YFACtor
Queries "y-factor" results.

Return values:

<TraceData> For any graphical result display, the command returns one result for each measurement point.
The unit depends on the result you are querying.

Example:

```
TRAC? TRACE1,GAIN
```

Queries the "gain" results for the first trace.

Usage: Query only

Manual operation: See "Noise Figure" on page 16
See "Gain" on page 17
See "Noise Temperature" on page 17
See "Y-Factor" on page 18
See "ENR Measured" on page 19
See "Power (Hot)" on page 20
See "Power (Cold)" on page 20
See "Cal Y-Factor" on page 21
See "Cal Power (Hot)" on page 21
See "Cal Power (Cold)" on page 22
See "Result Table" on page 22

7.7 Defining the measurement frequency

The following commands are necessary to define the frequency characteristics of the "noise figure" measurement.

[SENSe:]CONFigure:FREQuency:CONTinuous....107
[SENSe:]CONFigure:FREQuency:SINGle....108
[SENSe:]CONFigure:LIST:CONTinuous....108
[SENSe:]CONFigure:LIST:SINGle....108
[SENSe:]FREQuency:CENTer....108
[SENSe:]FREQuency:TABLe:DATA....109
[SENSe:]FREQuency:LIST:DATA....109
[SENSe:]BANDwidth:LIST:DATA....109
[SENSe:]FREQuency:POINts....110
[SENSe:]FREQuency:SINGle....110
[SENSe:]FREQuency:SINGle:COUPled....110
[SENSe:]FREQuency:SPAN....111
[SENSe:]FREQuency:STARt....111
[SENSe:]FREQuency:STEP....111
[SENSe:]FREQuency:STOP....111

[SENSe:]CONFigure:FREQuency:CONTinuous

This command configures the software to perform a single frequency measurement in continuous sweep mode.

Example:
```
FREQ:SING 20MHz
```
Defines a measurement frequency of 20 MHz.
```
CONF:FREQ:CONT
INIT
```
Selects and initiates a single frequency measurement.

Usage: Event

Manual operation: See "Tuning Mode" on page 44

[SENSe:]CONFigure:FREQuency:SINGle

This command configures the software to perform a single frequency measurement in single sweep mode.

Example: `FREQ:SING 20MHz`
Defines a measurement frequency of 20 MHz.
`CONF:FREQ:SING`
`INIT`
Selects and initiates a single frequency measurement.

Usage: Event

Manual operation: See "Tuning Mode" on page 44

[SENSe:]CONFigure:LIST:CONTinuous

This command configures the software to perform a frequency list measurement in continuous sweep mode.

Example: `CONF:LIST:CONT`
`INIT`
Selects and initiates a frequency list measurement.

Usage: Event

Manual operation: See "Tuning Mode" on page 44

[SENSe:]CONFigure:LIST:SINGle

This command configures the software to perform a measurement in single frequency tuning mode.

Example: `CONF:LIST:SING`
`INIT`
Selects and initiates a single frequency measurement.

Example: See Chapter 7.21, "Programming example: measuring a noise figure", on page 183

Usage: Event

Manual operation: See "Tuning Mode" on page 44

[SENSe:]FREQuency:CENTer <Frequency>

This command defines the center frequency.

Parameters:
<Frequency> The allowed range and f_{max} is specified in the data sheet.
*RST: fmax/2
Default unit: Hz

Example: `FREQ:CENT 100 MHz`
`FREQ:CENT:STEP 10 MHz`
`FREQ:CENT UP`
Sets the center frequency to 110 MHz.

Manual operation: See "Center" on page 45

[SENSe:]FREQuency:TABLe:DATA <Frequency>...

This command defines the contents of the frequency table.

The command overwrites the current contents of the frequency table.

Parameters:

<Frequency> Defines a frequency for each entry in the frequency table. A frequency table can contain up to 10001 entries.

Range: 0 Hz to fmax
Default unit: HZ

Example: `FREQ:TABL:DATA 100MHZ,200MHZ,300MHZ,400MHZ,500MHZ`
Creates a frequency table with five entries.

Manual operation: See "Populate Table" on page 49

[SENSe:]FREQuency:LIST:DATA {<RFFrequency>, <LOFrequency>, <IFFrequency>}...

Queries the RF, LO and IF frequency.

Parameters:

<RFFrequency> Default unit: Hz

<LOFrequency> Default unit: Hz

<IFFrequency> Default unit: Hz

Example: `SENS:FREQ:LIST:DATA?`

Manual operation: See "Populate Table" on page 49

[SENSe:]BANDwidth:LIST:DATA {<Frequency>, <Bandwidth>, <SweepTime>}...

Queries the RF, RBW and sweep time.

Parameters:

<Frequency> <numeric value>
Default unit: Hz

<Bandwidth> <numeric value>
Default unit: Hz

<SweepTime> <numeric value>
Default unit: s

Example: `SENS:BAND:LIST:DATA?`

Manual operation: See "Populate Table" on page 49

[SENSe:]FREQuency:POINts <SweepPoints>

This command defines the number of measurement points analyzed during a sweep.

Parameters:

<SweepPoints> Range: 1 to 10001
*RST: 20

Example: `SWE:POIN 100`
Defines 100 measurement points.

Example: See Chapter 7.21, "Programming example: measuring a noise figure", on page 183

Manual operation: See "(Measurement) Points" on page 45
See "(Measurement) Points" on page 47

[SENSe:]FREQuency:SINGle <Frequency>

This command defines the frequency for single frequency measurements.

Parameters:

<Frequency> The minimum and maximum frequency depend on the hardware. Refer to the datasheet for details.
*RST: 100 MHz
Default unit: HZ

Example: `FREQ:SING 200MHZ`
Defines a measurement frequency of 200 MHz.

Manual operation: See "Center" on page 45
See "Single (Frequency)" on page 46

[SENSe:]FREQuency:SINGle:COUPled <State>

Couples or decouples frequency selection to the contents of a sweep list.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Decouples frequency selection

ON | 1
Couples frequency selection

*RST: 0

Example: `SENS:FREQ:SING:COUP ON`

Manual operation: See "Coupled to Sweep List" on page 46

[SENSe:]FREQuency:SPAN <Span>

This command defines the frequency span.

If you change the span, the application creates a new frequency list.

Parameters:
<Span> Default unit: Hz

Example: `FREQ:SPAN 500MHZ`
Defines a span of 500 MHz.

Manual operation: See "Span" on page 45

[SENSe:]FREQuency:STARt <Frequency>

This command defines the start frequency.

If you change the start frequency, the application creates a new frequency list.

Parameters:
<Frequency> *RST: RST value
Default unit: HZ

Example: `FREQ:STAR 900MHZ`
Defines a start frequency of 900 MHz.

Example: See Chapter 7.21, "Programming example: measuring a noise figure", on page 183

Manual operation: See "Start and Stop Frequency" on page 45

[SENSe:]FREQuency:STEP <Stepsize>

This command defines the frequency stepsize in the frequency table.

The stepsize corresponds to the distance from one measurement point to another.

If you change the stepsize, the application creates a new frequency list.

Parameters:
<Stepsize> Range: 0 Hz to span
*RST: 100 MHz
Default unit: HZ

Example: `FREQ:STEP 100MHZ`
Defines a stepsize of 100 MHz.

Manual operation: See "Step" on page 45

[SENSe:]FREQuency:STOP <Frequency>

This command defines the stop frequency.

If you change the stop frequency, the application creates a new frequency list.

Parameters:
<Frequency> *RST: RST value
Default unit: HZ

Example: FREQ:STOP 900MHZ
Defines a stop frequency of 900 MHz.

Example: See Chapter 7.21, "Programming example: measuring a noise figure", on page 183

Manual operation: See "Start and Stop Frequency" on page 45

7.8 Selecting DUT characteristics

The following commands are necessary to define DUT characteristics.

[SENSe:]CONFigure:MODE:SYSTem:LO 112
[SENSe:]CONFigure:MODE:SYSTem:LO:FREQuency 112
[SENSe:]CONFigure:MODE:DUT 113
[SENSe:]CORRection:IREJection 113

[SENSe:]CONFigure:MODE:SYSTem:LO <LOType>

This command selects the type of local oscillator you are using.

The command is available for measurements on frequency converting DUTs [SENSe:]CONFigure:MODE:DUT().

Parameters:
<LOType> FIXed | VARiable

FIXed
The local oscillator is used as a fixed frequency source.
The IF is variable.

Example:
```
CONF:MODE:DUT DOWN
CONF:MODE:SYST:LO FIX
CONF:MODE:SYST:LO:FREQ 1GHZ
```
Selects a fixed LO frequency (= 1 GHz) on a down converting DUT.

Manual operation: See "Mode" on page 50

[SENSe:]CONFigure:MODE:SYSTem:LO:FREQuency <LOFrequency>

This command defines the frequency for DUTs with a fixed LO.

Parameters:
<LOFrequency> Range: 0 Hz to 100 GHz
*RST: 10 MHz, if frequency converting mode has been selected
Default unit: HZ

Example: `CONF:MODE:SYST:LO:FREQ 1GHZ`
Defines a fixed LO frequency of 1 GHz.

Manual operation: See "LO Fixed" on page 50

[SENSe:]CONFigure:MODE:DUT <DUTType>

This command selects the type of DUT you are testing.

Note that you have to use `[SENSe:]CONFigure:MODE:SYSTem:LO` to select the fixed LO.

Parameters:

<DUTType> AMPLifier | DDOWnconv | DOWNconv | UPConv

AMPLifier
Measurements on fixed frequency DUTs.

DOWNconv
Measurements on down-converting DUTs.

UPConv
Measurements on up-converting DUTs.

*RST: AMPLifier

Example: `CONF:MODE:DUT DOWN`
Selects the measurement mode for a down-converting DUT.

Manual operation: See "Mode" on page 50

[SENSe:]CORRection:IREJection <ImageRejection>

This command defines the image frequency rejection for the DUT.

Parameters:

<ImageRejection> Range: 0 to 999.99
*RST: 999.99
Default unit: DB

Example: `CORR:IREJ 0`
Turns image rejection off.

Manual operation: See "Image Rejection" on page 50

7.9 Configuring the noise source

The following commands are necessary to define the noise source characteristics.

[SENSe:]CORRection:ENR:CALibration:SPOT:COLD 114
[SENSe:]CORRection:ENR:CALibration:SPOT:HOT 114
[SENSe:]CORRection:ENR:CALibration:MODE 115
[SENSe:]CORRection:ENR:CALibration:SPOT 115
[SENSe:]CORRection:ENR:CALibration:TABLe:SELect 115

[SENSe:]CORRection:ENR:CALibration:TYPE 116
[SENSe:]CORRection:ENR:COMMon 116
[SENSe:]CORRection:ENR[:MEASurement]:TABLe[:DATA] 117
[SENSe:]CORRection:ENR[:MEASurement]:TABLe:DELete 117
[SENSe:]CORRection:ENR[:MEASurement]:TABLe:LIST? 117
[SENSe:]CORRection:ENR[:MEASurement]:TABLe:SELect 118
[SENSe:]CORRection:ENR[:MEASurement]:TABLe:TEMPerature[:DATA] 118
[SENSe:]CORRection:ENR[:MEASurement]:TABLe:TEMPerature:DELete 118
[SENSe:]CORRection:ENR[:MEASurement]:TABLe:TEMPerature:LIST? 118
[SENSe:]CORRection:ENR[:MEASurement]:MODE 119
[SENSe:]CORRection:ENR[:MEASurement]:SPOT 119
[SENSe:]CORRection:ENR[:MEASurement]:TYPE 119
[SENSe:]CORRection:ENR[:MEASurement]:SPOT:COLD 120
[SENSe:]CORRection:ENR[:MEASurement]:SPOT:HOT 120
[SENSe:]CORRection:TEMPerature 121
[SENSe:]CORRection:ENR[:MEASurement]:SNS:SRNumber 121
[SENSe:]CORRection:ENR:CALibration:SNS:SRNumber 121

[SENSe:]CORRection:ENR:CALibration:SPOT:COLD <Temperature>

This command defines a constant temperature of a resistor not supplied with power (T_{cold}) used during calibration.

The command is available when you have selected a noise source with resistor characteristics with `[SENSe:]CORRection:ENR:CALibration:TYPE`.

Parameters:

<Temperature> Temperature in degrees Kelvin.

*RST: 77 K
Default unit: K

Example:

```
CORR:ENR:CAL:TYPE RES
CORR:ENR:CAL:SPOT:COLD 100
```

Defines a cold temperature of 100 K.

Manual operation: See "Calibration" on page 54

[SENSe:]CORRection:ENR:CALibration:SPOT:HOT <Temperature>

This command defines a constant temperature of a resistor supplied with power (T_{hot}) used during calibration.

The command is available when you have selected a noise source with resistor characteristics with `[SENSe:]CORRection:ENR:CALibration:TYPE`.

Parameters:

<Temperature> Temperature in degrees Kelvin.

*RST: 77 K
Default unit: K

Example: CORR:ENR:TYPE RES
CORR:ENR:CAL:SPOT:HOT 300
Defines a cold temperature of 300 K.

Manual operation: See "Calibration" on page 54

[SENSe:]CORRection:ENR:CALibration:MODE <Mode>

This command selects the ENR mode for the calibration.

This command is available when you use different noise sources for calibration and measurement ([SENSe:]CORRection:ENR:COMMon OFF).

Parameters:

<Mode> SPOT | TABLe

SPOT
Uses a constant ENR value for all measurement points (see [SENSe:]CORRection:ENR:CALibration:SPOT).

TABLe
Uses the contents of the ENR table.

*RST: SPOT

Example: CORR:ENR:CAL:MODE SPOT
Uses a constant ENR value for all measurement points.

Manual operation: See "Calibration" on page 54

[SENSe:]CORRection:ENR:CALibration:SPOT <ENR>

This command defines the constant ENR for all measurement points during calibration.

This command is available when you use different noise sources for calibration and measurement ([SENSe:]CORRection:ENR:COMMon OFF).

Parameters:

<ENR> Range: -999.99 to 999.99
*RST: 15
Default unit: DB

Example: CORR:ENR:CAL:MODE SPOT
CORR:ENR:CAL:SPOT 30
Selects constant ENR value mode and defines an ENR of 30 dB for all measurement points.

Manual operation: See "Calibration" on page 54

[SENSe:]CORRection:ENR:CALibration:TABLe:SELect <TableName>

This command selects an ENR or temperature table for calibration.

Note that the contents of the table are independent of whether you use it for calibration or the actual measurement. When you want to edit a table, regardless if you want to use it later for a measurement or for calibration, you have to use `[SENSe:]CORRection:ENR[:MEASurement]:TABLe:SELect`. This command only selects a table for calibration.

This command is available when you use different noise sources for calibration and measurement (`[SENSe:]CORRection:ENR:COMMon OFF`).

Parameters:

<TableName> String containing the table name.

Example: `CORR:ENR:MEAS:TABL:SEL 'ENRTable'`
Selects a table called 'ENRTable'.

Manual operation: See "Calibration" on page 54
See "New" on page 57

[SENSe:]CORRection:ENR:CALibration:TYPE <Type>

This command selects the type of noise source you are using for the calibration.

Parameters:

<Type>

DIODe
Selects a noise source with diode characteristics.

RESistor
Selects a noise source with resistor characteristics.
When you select this noise source type, the application automatically selects the manual measurement mode (see `[SENSe:]CONFigure:CONTrol`).

SMARt
Selects a smart noise source.

*RST: DIODe

Example: `CORR:ENR:CAL:TYPE RES`
Selects a noise source with resistor characteristics.

Manual operation: See "Noise Source" on page 53

[SENSe:]CORRection:ENR:COMMon <State>

This command turns the use of a common ENR on or off.

For more information see "Common Noise Source" on page 54.

Parameters:

<State> ON | OFF | 1 | 0

Example: `CORR:ENR:COMM ON`
Turns the use of a common ENR on.

Manual operation: See "Common Noise Source" on page 54

[SENSe:]CORRection:ENR[:MEASurement]:TABLe[:DATA] {<FrequencyENR>, <ENR>}...

This command defines the contents of the currently selected ENR table.

Define an ENR for all measurement points.

Each entry of the ENR table consists of one measurement point and the corresponding ENR. The individual values are separated by commas or spaces. The table can contain up to 10001 entries.

If you create a new table with this command, it overwrites the current entries of the frequency list.

To select the ENR table to edit, use `[SENSe:]CORRection:ENR[:MEASurement]:TABLe[:DATA]`.

Parameters:

<FrequencyENR> Frequency of the measurement point.
Range: 0 Hz to 999.99 GHz
Default unit: HZ

<ENR> Default unit: DB

Example: `CORR:ENR:MEAS:TABL:DATA 1MHZ,10,2MHZ,12`
Defines a new ENR table with two measurement points.

Example: See Chapter 7.21, "Programming example: measuring a noise figure", on page 183

Manual operation: See "New" on page 57
See "Edit" on page 57
See "Edit Table" on page 58

[SENSe:]CORRection:ENR[:MEASurement]:TABLe:DELete <TableName>

This command deletes a temperature table.

Setting parameters:

<TableName> String containing the name of the table.

Example: `CORR:ENR:MEAS:TABL:TEMP:DEL 'TemperatureTable'`
Deletes the table with the name 'TemperatureTable'.

Usage: Setting only

Manual operation: See "Delete" on page 57

[SENSe:]CORRection:ENR[:MEASurement]:TABLe:LIST?

Return values:

<Tables> <list>

Usage: Query only

[SENSe:]CORRection:ENR[:MEASurement]:TABLe:SELect <TableName>

This command selects an ENR or temperature table for the actual measurement.

When you want to edit a table, regardless if you want to use it later for a measurement or for calibration, you have to use this command. `[SENSe:]CORRection:ENR:CALibration:TABLe:SELect` only selects a table for calibration.

Parameters:
<TableName>

Manual operation: See "Measurement" on page 53
See "New" on page 57
See "Edit" on page 57

[SENSe:]CORRection:ENR[:MEASurement]:TABLe:TEMPerature[:DATA]
{<Frequency>, <Thot>, <Tcold>}...

Parameters:
<Frequency> Default unit: HZ

<Thot> Default unit: K

<Tcold> Default unit: K

Manual operation: See "New" on page 57
See "Edit" on page 57
See "Edit Table" on page 58

[SENSe:]CORRection:ENR[:MEASurement]:TABLe:TEMPerature:DELete
<TableName>

This command deletes a temperature table.

Setting parameters:
<TableName> String containing the name of the table.

Example: `CORR:ENR:MEAS:TABL:TEMP:DEL 'TemperatureTable'`
Deletes the table with the name 'TemperatureTable'.

Usage: Setting only

Manual operation: See "Delete" on page 57

[SENSe:]CORRection:ENR[:MEASurement]:TABLe:TEMPerature:LIST?

This command queries all temperature tables available in the application.

Return values:
<Tables> <list>
String containing the names of the tables as a comma separated list.

Example: CORR:ENR:TABL:TEMP:LIST
would return, e.g.
'Table1,Table2,Table3'

Usage: Query only

[SENSe:]CORRection:ENR[:MEASurement]:MODE <Mode>

This command selects the ENR mode for the actual measurement.

Parameters:

<Mode> SPOT | TABLe

SPOT
Uses a constant ENR value for all measurement points (see [SENSe:]CORRection:ENR[:MEASurement]:SPOT).

TABLe
Uses the contents of the ENR table.

*RST: SPOT

Example: CORR:ENR:MODE SPOT
Uses a constant ENR value for all measurement points.

Example: See Chapter 7.21, "Programming example: measuring a noise figure", on page 183

Manual operation: See "Measurement" on page 53

[SENSe:]CORRection:ENR[:MEASurement]:SPOT <ENR>

This command defines the constant ENR for all measurement points during the actual measurement.

Parameters:

<ENR> *RST: 15
Default unit: DB

Example: CORR:ENR:MODE SPOT
CORR:ENR:SPOT 30
Selects constant ENR value mode and defines an ENR of 30 dB for all measurement points.

Manual operation: See "Measurement" on page 53

[SENSe:]CORRection:ENR[:MEASurement]:TYPE <Type>

This command selects the type of noise source you are using for the measurement.

Parameters:

<Type> **DIODe**
Selects a noise source with diode characteristics.

RESistor
Selects a noise source with resistor characteristics.
When you select this noise source type, the application automatically selects the manual measurement mode (see `[SENSe:]CONFigure:CONTrol`).

SMARt
Selects a smart noise source.

*RST: DIODe

Example: `CORR:ENR:TYPE RES`
Selects a noise source with resistor characteristics.

Manual operation: See "Noise Source" on page 53
See "Noise Source" on page 56

[SENSe:]CORRection:ENR[:MEASurement]:SPOT:COLD <Temperature>

This command defines a constant temperature of a resistor not supplied with power (T_{cold}) used during measurements.

The command is available when you have selected a noise source with resistor characteristics with `[SENSe:]CORRection:ENR[:MEASurement]:TYPE`.

Parameters:
<Temperature> Temperature in degrees Kelvin.

*RST: 77 K
Default unit: K

Example:
```
CORR:ENR:TYPE RES
CORR:ENR:SPOT:COLD 100
```
Defines a cold temperature of 100 K.

Manual operation: See "Measurement" on page 53

[SENSe:]CORRection:ENR[:MEASurement]:SPOT:HOT <Temperature>

This command defines a constant temperature of a resistor supplied with power (T_{hot}) used during measurements.

The command is available when you have selected a noise source with resistor characteristics with `[SENSe:]CORRection:ENR[:MEASurement]:TYPE` .

Parameters:
<Temperature> Temperature in degrees Kelvin.

*RST: 77 K
Default unit: K

Example:
```
CORR:ENR:TYPE RES
CORR:ENR:SPOT:HOT 300
```
Defines a cold temperature of 300 K.

Manual operation: See "Measurement" on page 53

[SENSe:]CORRection:TEMPerature <Temperature>

This command defines the room temperature of the measurement environment. The temperature is taken into account when calculating noise results.

Parameters:

<Temperature> Range: 278.15 to 318.15
*RST: 293
Default unit: K

Example: `CORR:TEMP 291.50`
Specifies a room temperature of 291.50 Kelvin (18.5 C).

Manual operation: See "Temperature" on page 55

[SENSe:]CORRection:ENR[:MEASurement]:SNS:SRNumber <SerialNumber>

This command sets and queries the measurement noise source smart noise source serial number.

Parameters:

<SerialNumber>

Manual operation: See "Noise Source" on page 53

[SENSe:]CORRection:ENR:CALibration:SNS:SRNumber <SerialNumber>

This command sets and queries the calibration noise source smart noise source serial number.

Parameters:

<SerialNumber>

Manual operation: See "Noise Source" on page 53

7.10 Configuring additional loss

The following commands are necessary to define loss resulting from equipment in the measurement setup.

[SENSe:]CORRection:LOSS:CALibration:MODE....122
[SENSe:]CORRection:LOSS:CALibration:SPOT....122
[SENSe:]CORRection:LOSS:CALibration:TABLe:DELete....122
[SENSe:]CORRection:LOSS:CALibration:TABLe:LIST?....123
[SENSe:]CORRection:LOSS:CALibration:TABLe:SELect....123
[SENSe:]CORRection:LOSS:CALibration:TABLe[:DATA]....123
[SENSe:]CORRection:LOSS:CALibration:TEMPerature....124
[SENSe:]CORRection:LOSS:INPut:MODE....124
[SENSe:]CORRection:LOSS:INPut:SPOT....124
[SENSe:]CORRection:LOSS:INPut:TABLe[:DATA]....125
[SENSe:]CORRection:LOSS:INPut:TABLe:DELete....125

[SENSe:]CORRection:LOSS:INPut:TABLe:LIST? 125
[SENSe:]CORRection:LOSS:INPut:TABLe:SELect 125
[SENSe:]CORRection:LOSS:INPut:TEMPerature 126
[SENSe:]CORRection:LOSS:OUTPut:MODE 126
[SENSe:]CORRection:LOSS:OUTPut:SPOT 126
[SENSe:]CORRection:LOSS:OUTPut:TABLe[:DATA] 127
[SENSe:]CORRection:LOSS:OUTPut:TABLe:DELete 127
[SENSe:]CORRection:LOSS:OUTPut:TABLe:LIST? 127
[SENSe:]CORRection:LOSS:OUTPut:TABLe:SELect 127
[SENSe:]CORRection:LOSS:OUTPut:TEMPerature 128

[SENSe:]CORRection:LOSS:CALibration:MODE <Mode>

This command selects the input loss mode.

Parameters:

<Mode> SPOT | TABLe

SPOT
Uses a constant calibration loss value for all measurement points (see `[SENSe:]CORRection:LOSS:CALibration:SPOT` on page 122).

TABLe
Uses the contents of the calibration loss table.

*RST: SPOT

Example:
```
CORR:LOSS:INP:MODE SPOT
CORR:LOSS:INP:SPOT 10
```
Selects constant calibration loss mode and defines an input loss of 10 dB for all measurement points.

Manual operation: See "Calibration Loss" on page 61

[SENSe:]CORRection:LOSS:CALibration:SPOT <Loss>

This command defines a constant calibration loss for all measurement points.

Parameters:

<Loss>
Range: -999.99 to 999.99
*RST: 0 dB
Default unit: dB

Example:
```
CORR:LOSS:INP:MODE SPOT
CORR:LOSS:INP:SPOT 10
```
Selects constant calibration loss mode and defines an input loss of 10 dB for all measurement points.

Manual operation: See "Calibration Loss" on page 61

[SENSe:]CORRection:LOSS:CALibration:TABLe:DELete <TableName>

This command deletes a calibration loss table.

Setting parameters:

<TableName> String containing the name of the table.

Example: `CORR:LOSS:CAL:TABL:DEL 'CalibrationLoss'`
Deletes the table with the name 'CalibrationLoss'.

Usage: Setting only

Manual operation: See "Delete" on page 63

[SENSe:]CORRection:LOSS:CALibration:TABLe:LIST?

This command queries all calibration loss tables available in the application.

Example: `CORR:LOSS:CAL:TABL:LIST?`
Result:
`'Table1,Table2,Table3'`

Usage: Query only

[SENSe:]CORRection:LOSS:CALibration:TABLe:SELect <TableName>

This command selects a calibration loss table.

Parameters:

<TableName> String containing the table name.

Example: `CORR:LOSS:CAL:TABL:SEL 'CalibrationLoss'`
Selects a table called CalibrationLoss'.

Manual operation: See "Calibration Loss" on page 61

[SENSe:]CORRection:LOSS:CALibration:TABLe[:DATA] {<Frequency>, <Loss>}...

This command defines the contents of the currently selected calibration loss table.

Each entry of the loss table consists of one measurement point and the corresponding loss. The table can contain up to 10001 entries.

If you create a new table with this command, it overwrites the current entries of the loss table.

Parameters:

<Frequency> Frequency of the measurement point.

Range: 0 Hz to 999.99 GHz
Default unit: HZ

<Loss> Loss of the measurement point.

Range: -999.99 GHz to 999.99 GHz
Default unit: DB

Example: `CORR:LOSS:CAL:TABL 1MHz,10,2MHz,12`
Defines a new calibration loss table with two measurement points.

Manual operation: See "New" on page 63
See "Edit" on page 63

[SENSe:]CORRection:LOSS:CALibration:TEMPerature <Temperature>

The specified temperature at the time of measurement is considered in the loss calculation.

Parameters:
<Temperature> Default unit: K

Example: `SENS:CORR:LOSS:CAL:TEMP 296.5`
Calibration loss is corrected for a temperature of 296.5 K (23.35° C).

Manual operation: See "Calibration Loss" on page 61

[SENSe:]CORRection:LOSS:INPut:MODE <Mode>

This command selects the input loss mode.

Parameters:
<Mode> SPOT | TABLe

SPOT
Uses a constant input loss value for all measurement points (see `[SENSe:]CORRection:LOSS:INPut:SPOT` on page 124).

TABLe
Uses the contents of the input loss table.

*RST: SPOT

Example: `CORR:LOSS:INP:MODE SPOT`
Selects constant input loss.

Manual operation: See "Input Loss" on page 60

[SENSe:]CORRection:LOSS:INPut:SPOT <Loss>

This command defines a constant input loss for all measurement points.

Parameters:
<Loss> Range: -999.99 to 999.99
*RST: 0 dB
Default unit: DB

Example: `CORR:LOSS:INP:MODE SPOT`
`CORR:LOSS:INP:SPOT 10`
Selects constant input loss mode and defines an input loss of 10 dB for all measurement points.

Manual operation: See "Input Loss" on page 60

[SENSe:]CORRection:LOSS:INPut:TABLe[:DATA] {<Frequency>, <Loss>}...

This command defines the contents of the currently selected input loss table.

Each entry of the loss table consists of one measurement point and the corresponding loss. The table can contain up to 10001 entries.

The table should contain an input loss for all measurement points.

If you create a new table with this command, it will overwrite the current entries of the loss table.

Parameters:

<Frequency> Frequency of the measurement point.

Range: 0 dB to 999.99 dB
Default unit: HZ

<Loss> Loss of the measurement point.

Range: -999.99 dB to 999.99 dB
Default unit: DB

Example: `CORR:LOSS:INP:TABL 1MHz,10,2MHz,12`
Defines a new input loss table with two measurement points.

Manual operation: See "Edit Table" on page 58
See "New" on page 63
See "Edit" on page 63

[SENSe:]CORRection:LOSS:INPut:TABLe:DELete <TableName>

This command deletes an input loss table.

Setting parameters:

<TableName> String containing the name of the table.

Example: `CORR:LOSS:INP:TABL:DEL 'InputLoss'`
Deletes the table with the name 'InputLoss'.

Usage: Setting only

Manual operation: See "Delete" on page 63

[SENSe:]CORRection:LOSS:INPut:TABLe:LIST?

This command queries all input loss tables available in the application.

Example: `CORR:LOSS:INP:TABL:LIST?`
Result:
`'Table1,Table2,Table3'`

Usage: Query only

[SENSe:]CORRection:LOSS:INPut:TABLe:SELect <TableName>

This command selects an input loss table.

Parameters:
<TableName> String containing the table name.

Example: `CORR:LOSS:INP:TABL:SEL 'InputLoss'`
Selects a table called 'InputLoss'.

Manual operation: See "Input Loss" on page 60

[SENSe:]CORRection:LOSS:INPut:TEMPerature <Temperature>

The specified temperature at the time of measurement is considered in the loss calculation.

Parameters:
<Temperature> Default unit: K

Example: `SENS:CORR:LOSS:INP:TEMP 296.5`
Input loss is corrected for a temperature of 296.5 K (23.35° C).

Manual operation: See "Input Loss" on page 60

[SENSe:]CORRection:LOSS:OUTPut:MODE <Mode>

This command selects the output loss mode.

Parameters:
<Mode> SPOT | TABLe

SPOT
Uses a constant output loss value for all measurement points (see `[SENSe:]CORRection:LOSS:OUTPut:SPOT` on page 126).

TABLe
Uses the contents of the output loss table.

*RST: SPOT

Example: `CORR:LOSS:OUTP:MODE SPOT`
Selects constant output loss.

Manual operation: See "Output Loss" on page 61

[SENSe:]CORRection:LOSS:OUTPut:SPOT <Loss>

This command defines a constant output loss for all measurement points.

Parameters:
<Loss> Range: -999.99 to 999.99
*RST: 0 dB
Default unit: DB

Example: `CORR:LOSS:OUTP:MODE SPOT`
`CORR:LOSS:OUTP:SPOT 10`
Selects constant output loss mode and defines an output loss of 10 dB for all measurement points.

Manual operation: See "Output Loss" on page 61

[SENSe:]CORRection:LOSS:OUTPut:TABLe[:DATA] {<Frequency>, <Loss>}...

This command defines the contents of the currently selected output loss table.

The table should contain an output loss for all measurement points.

Each entry of the loss table consists of one measurement point and the corresponding loss. The table can contain up to 10001 entries.

If you create a new table with this command, it will overwrite the current entries of the frequency list.

Parameters:

<Frequency> Frequency of the measurement point.

Range: 0 dB to 999.99 dB
Default unit: HZ

<Loss> Loss of the measurement point.

Range: -999.99 dB to 999.99 dB
Default unit: DB

Example: `CORR:LOSS:OUTP:TABL 1MHz,10,2MHz,12`
Defines a new output loss table with two measurement points.

Manual operation: See "Edit Table" on page 58
See "New" on page 63
See "Edit" on page 63

[SENSe:]CORRection:LOSS:OUTPut:TABLe:DELete <TableName>

Setting parameters:

<TableName>

Usage: Setting only

Manual operation: See "Delete" on page 63

[SENSe:]CORRection:LOSS:OUTPut:TABLe:LIST?

This command queries all output loss tables available in the application.

Example: `CORR:LOSS:OUTP:TABL:LIST?`
Result:
`'Table1,Table2,Table3'`

Usage: Query only

[SENSe:]CORRection:LOSS:OUTPut:TABLe:SELect <TableName>

Parameters:

<TableName>

Manual operation: See "Output Loss" on page 61

[SENSe:]CORRection:LOSS:OUTPut:TEMPerature <Temperature>

The specified temperature at the time of measurement is considered in the loss calculation.

Parameters:

<Temperature> numeric value
Default unit: K

Example: `SENS:CORR:LOSS:OUTP:TEMP 296.5`
Output loss is corrected for a temperature of 296.5 K (23.35° C).

Manual operation: See "Output Loss" on page 61

7.11 Configuring the analyzer

The following commands are necessary to configure the analyzer.

[SENSe:]BWIDth[:RESolution] 128
[SENSe:]BANDwidth[:RESolution] 128
[SENSe:]BWIDth:RESolution:AUTO 129
[SENSe:]BANDwidth:RESolution:AUTO 129
[SENSe:]CONFigure:CORRection 129
[SENSe:]CORRection[:STATe] 130
[SENSe:]CORRection:RECall 130
[SENSe:]CORRection:SAVE 130
[SENSe:]SWEep:COUNt 131
[SENSe:]SWEep:TIME 131
[SENSe:]SWEep:TIME:AUTO 131
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel 132
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel:AUTO 132
INPut<ip>:ATTenuation 132
SYSTem:CONFigure:DUT:GAIN 133
SYSTem:CONFigure:DUT:STIMe 133

[SENSe:]BWIDth[:RESolution] <Bandwidth>
[SENSe:]BANDwidth[:RESolution] <Bandwidth>

This command defines the resolution bandwidth and decouples the resolution bandwidth from the span.

Example: `BAND 1 MHz`
Sets the resolution bandwidth to 1 MHz

Manual operation: See "Resolution Bandwidth (RBW)" on page 65

[SENSe:]BWIDth:RESolution:AUTO <State>
[SENSe:]BANDwidth:RESolution:AUTO <State>

If enabled, the resolution bandwidth is selected automatically, depending on the current frequency of the sweep point, as defined in the frequency table (see Chapter 5.2.3, "Using a frequency table", on page 47).

If disabled, the RBW defined by `[SENSe:]BANDwidth[:RESolution]` is used.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example: `SENS:BAND:RES:AUTO ON`

Manual operation: See "Resolution Bandwidth (RBW)" on page 65

[SENSe:]CONFigure:CORRection

This command configures the software to perform calibration measurements.

Using `INITiate<n>[:IMMediate]` then initiates a calibration instead of the actual measurement, until you deliberately select one of the normal measurements again with one of the following commands.

- `[SENSe:]CONFigure:FREQuency:CONTinuous`
- `[SENSe:]CONFigure:FREQuency:SINGle`
- `[SENSe:]CONFigure:LIST:CONTinuous`
- `[SENSe:]CONFigure:LIST:SINGle`

Note that calibration data is used only when the second stage correction mode has been turned on with `[SENSe:]CORRection[:STATe]`.

Example:
```
//Turn on second stage correction
CORR ON
//Configure application to run calibration measurement
CONF:CORR
//Initiate calibration with synchronization to end of measurement
INIT;*OPC
//Return to normal measurement (single sweep list mode)
CONF:LIST:SING
//Initiate a calibrated measurement with synchronization to end of measurement
INIT;*OPC
```

Example: See Chapter 7.21, "Programming example: measuring a noise figure", on page 183

Usage: Event

Manual operation: See "2nd Stage Correction" on page 65
See "Calibrate" on page 75

[SENSe:]CORRection[:STATe] <State>

This command includes or excludes calibration data in the actual measurement (see "2nd Stage Correction" on page 65 for more information).

Parameters:
<State> ON | OFF | 1 | 0
*RST: 0

Example: `CORR ON`
Includes calibration data in the measurement.

Example: See Chapter 7.21, "Programming example: measuring a noise figure", on page 183

Manual operation: See "2nd Stage Correction" on page 65

[SENSe:]CORRection:RECall <recallfilepath>

Sets the calibration results recall filepath and recalls the calibration results.

Setting parameters:
<recallfilepath>

Example: `SENS:CORR:REC 'filepath'`
This command will recall the calibration results from a selected file with extension `.dfl`.

Usage: Setting only

Manual operation: See "Calibration Recall" on page 35

[SENSe:]CORRection:SAVE <savefilepath>

Queries and sets the calibration results save filepath and if set saves the calibration results.

Parameters:
<savefilepath>

Example: `SENS:CORR:SAVE?`
This will report an error -221 if calibration results are not available for saving. If calibration results are available the command will report a suggested filepath which includes the calibration results timestamp.
`SENS:CORR:SAVE 'filepath'`
This will report an error if calibration results are not available for saving. The command will save the calibration results to a filename with extension `.dfl`.

Manual operation: See "Calibration Save" on page 34

[SENSe:]SWEep:COUNt <Averages>

This command defines the number of measurements that are used to average the results.

Parameters:

<Averages> Number of measurements that are performed at a single frequency before average results are displayed.
If you set an average of 0 or 1, the application performs a single measurement at each frequency.

Range: 0 to 32767
*RST: 1

Example: `SWE:COUN 10`
The application averages 10 measurements before it displays the results.

Manual operation: See "Average" on page 66

[SENSe:]SWEep:TIME <Time>

This command defines the sweep time. It automatically decouples the time from any other settings.

Parameters:

<Time> refer to data sheet

*RST: depends on current settings (determined automatically)
Default unit: S

Manual operation: See "Sweep Time" on page 65

[SENSe:]SWEep:TIME:AUTO <State>

If enabled, the sweep time is automatically selected, depending on the current frequency of the sweep point, as defined in the frequency table (see Chapter 5.2.3, "Using a frequency table", on page 47).

If disabled, the value defined by `[SENSe:]SWEep:TIME` is used.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Manual operation: See "Sweep Time" on page 65

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel <ReferenceLevel>

This command defines the reference level (for all traces in all windows).

Suffix:
<n> irrelevant

<t> irrelevant

Parameters:
<ReferenceLevel> Range: see datasheet
*RST: -30 dBm
Default unit: DBM

Example: `DISP:TRAC:Y:RLEV -60dBm`

Manual operation: See "Ref Level" on page 66

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel:AUTO <State>

This command turns automatic determination of the reference level on and off.

Suffix:
<n> 1..n

<t> 1..n
irrelevant

Parameters:
<State> ON | OFF | 1 | 0

Example: `DISP:TRAC:Y:RLEV:AUTO ON`
Turns on automatic level detection.

Manual operation: See "Ref Level" on page 66

INPut<ip>:ATTenuation <Attenuation>

This command defines the total attenuation for RF input.

If you set the attenuation manually, it is no longer coupled to the reference level, but the reference level is coupled to the attenuation. Thus, if the current reference level is not compatible with an attenuation that has been set manually, the command also adjusts the reference level.

Suffix:
<ip> 1 | 2
irrelevant

Parameters:
<Attenuation> Range: see data sheet
Increment: 5 dB (with optional electr. attenuator: 1 dB)
*RST: 10 dB (AUTO is set to ON)
Default unit: DB

Example: `INP:ATT 30dB`
Defines a 30 dB attenuation and decouples the attenuation from the reference level.

Manual operation: See "RF Attenuation" on page 67

SYSTem:CONFigure:DUT:GAIN <Gain>

This command defines the expected "gain" of the DUT.

The application uses the "gain" for automatic reference level detection.

Parameters:
<Gain>
Range: 10 to 1000
*RST: 30
Default unit: DB

Example: `SYST:CONF:DUT:GAIN 25`
Defines "gain" of 25 dB.

Manual operation: See "Auto Level Range" on page 67

SYSTem:CONFigure:DUT:STIMe <SettlingTime>

This command defines the settling time of the noise source.

Parameters:
<SettlingTime>
Range: 0 s to 20 s
*RST: 50 ms
Default unit: S

Example: `SYST:CONF:DUT:STIM 1 s`
Defines a settling time of 1 second.

Manual operation: See "Settling Time" on page 66

7.12 Using the uncertainty calculator

The following commands are necessary to work with the measurement uncertainty calculator.

CALCulate<n>:UNCertainty:COMMon....134
CALCulate<n>:UNCertainty:DATA:FREQuency....134
CALCulate<n>:UNCertainty:DATA:GAIN....135
CALCulate<n>:UNCertainty:DATA:NOISe....135
CALCulate<n>:UNCertainty:DATA:RESults....135
CALCulate<n>:UNCertainty:ENR:CALibration:UNCertainty....136
CALCulate<n>:UNCertainty:ENR:CALibration:UNCertainty:COLD....136
CALCulate<n>:UNCertainty:ENR:CALibration:UNCertainty:HOT....137
CALCulate<n>:UNCertainty:ENR:UNCertainty....137
CALCulate<n>:UNCertainty:ENR:UNCertainty:COLD....137

CALCulate<n>:UNCertainty:ENR:UNCertainty:HOT 138
CALCulate<n>:UNCertainty:MATCh:DUT:IN:RL 138
CALCulate<n>:UNCertainty:MATCh:DUT:IN[:VSWR] 138
CALCulate<n>:UNCertainty:MATCh:DUT:OUT:RL 139
CALCulate<n>:UNCertainty:MATCh:DUT:OUT[:VSWR] 139
CALCulate<n>:UNCertainty:MATCh:PREamp:RL 139
CALCulate<n>:UNCertainty:MATCh:PREamp[:VSWR] 140
CALCulate<n>:UNCertainty:MATCh:SOURce:CALibration[:VSWR] 140
CALCulate<n>:UNCertainty:MATCh:SOURce:CALibration:RL 140
CALCulate<n>:UNCertainty:MATCh:SOURce:RL 141
CALCulate<n>:UNCertainty:MATCh:SOURce[:VSWR] 141
CALCulate<n>:UNCertainty:PREamp:GAIN 141
CALCulate<n>:UNCertainty:PREamp:NOISe 142
CALCulate<n>:UNCertainty:PREamp:STATe 142
CALCulate<n>:UNCertainty[:RESult]? 142
CALCulate<n>:UNCertainty:SANalyzer:GAIN:UNCertainty? 143
CALCulate<n>:UNCertainty:SANalyzer:NOISe:UNCertainty? 143

CALCulate<n>:UNCertainty:COMMon <State>

This command turns matching of the noise source characteristics used during calibration and measurement on and off.

This command is available when you use different noise sources for calibration and measurement (`[SENSe:]CORRection:ENR:COMMon OFF`).

Suffix:
<n> 1..n

Parameters:
<State> ON | OFF | 1 | 0
*RST: unavailable

Example: `CALC:UNC:COMM ON`
Applies the values of the calibration noise source to those of the measurement noise source.

Manual operation: See "Common Source for Meas and Cal" on page 69

CALCulate<n>:UNCertainty:DATA:FREQuency <Frequency>

This command defines the frequency for which the uncertainty should be calculated.

This command is available if you have turned automatic determination of the DUT characteristics off with`CALCulate<n>:UNCertainty:DATA:FREQuency` .

Suffix:
<n> 1..n

Parameters:
<Frequency> Frequency of the DUT.
*RST: 1 GHz
Default unit: HZ

Example: CALC:UNC:DATA:FREQ 100MHZ
Defines a frequency of 100 MHz.

Manual operation: See "Use Measurement Values" on page 71

CALCulate<n>:UNCertainty:DATA:GAIN <Gain>

This command defines the "gain" of the DUT.

This command is available if you have turned automatic determination of the DUT characteristics off with CALCulate<n>:UNCertainty:DATA:GAIN.

Suffix:
<n> 1..n

Parameters:
<Gain> "Gain" of the DUT.
*RST: 0 dB
Default unit: DB

Example: CALC:UNC:DATA:GAIN -5DB
Defines a DUT "gain" of -5 dB.

Manual operation: See "Use Measurement Values" on page 71

CALCulate<n>:UNCertainty:DATA:NOISe <NoiseLevel>

This command defines the noise level of the DUT.

This command is available if you have turned automatic determination of the DUT characteristics off with CALCulate<n>:UNCertainty:DATA:RESults.

Suffix:
<n> 1..n

Parameters:
<NoiseLevel> Noise level of the DUT.
*RST: 0 dB
Default unit: DB

Example: CALC:UNC:DATA:NOIS 10DB
Defines a DUT noise level of 10 dB.

Manual operation: See "Use Measurement Values" on page 71

CALCulate<n>:UNCertainty:DATA:RESults <State>

This command turns automatic determination of the DUT characteristics for the calculation of the uncertainty on and off.

Suffix:
<n> 1..n

Parameters:
<State> **ON | 1**
The application calculates the uncertainty with the DUT characteristics ("noise figure", "gain" and frequency) resulting from the "noise figure" measurement.

OFF | 0
The application calculates the uncertainty with the DUT characteristics ("noise figure", "gain" and frequency) based on the values you have defined manually.

Example: `CALC:UNC:DATA:RES ON`
Includes the uncertainty in the results displays.

CALCulate<n>:UNCertainty:ENR:CALibration:UNCertainty <Uncertainty>

This command defines the uncertainty of a calibration noise source.

This command is available when `[SENSe:]CORRection:ENR:COMMon` and `[SENSe:]CORRection:ENR:COMMon` are off.

If a smart noise source is used for calibration, the uncertainty values defined in the SNS table are used.

Suffix:
<n> 1..n

Parameters:
<Uncertainty> Uncertainty value of the noise source.
Refer to the data sheet of the noise source to determine its uncertainty.

*RST: 0.1 dB
Default unit: DB

Example: `CALC:UNC:ENR:CAL:UNC 0.05`
Defines an uncertainty of 0.05 dB.

Manual operation: See "ENR Uncert(ainty)" on page 70

CALCulate<n>:UNCertainty:ENR:CALibration:UNCertainty:COLD <Uncertainty>

Suffix:
<n> 1..n

Parameters:
<Uncertainty>

Manual operation: See "Temperature Uncert(ainty)" on page 70

CALCulate<n>:UNCertainty:ENR:CALibration:UNCertainty:HOT <Uncertainty>

This command defines the uncertainty of a calibration noise source.

This command is available when `[SENSe:]CORRection:ENR:COMMon` and `CALCulate<n>:UNCertainty:COMMon` are off.

Suffix:
<n> 1..n

Parameters:
<Uncertainty> Hot temperature uncertainty value of the noise source.
Refer to the data sheet of the noise source to determine its uncertainty.
*RST: 0 K

Example: `CALC:UNC:ENR:CAL:UNC:COLD 5 K`
Defines a high temperature uncertainty of 5 K.

Manual operation: See "Temperature Uncert(ainty)" on page 70

CALCulate<n>:UNCertainty:ENR:UNCertainty <Uncertainty>

This command defines the uncertainty of a noise source.

If the noise sources during calibration and measurement are different, the command defines the uncertainty of the measurement noise source.

If a smart noise source is used, the uncertainty values defined in the SNS table are used.

Suffix:
<n> 1..n

Parameters:
<Uncertainty> Uncertainty value of the noise source.
Refer to the data sheet of the noise source to determine its uncertainty.
*RST: 0.1 dB
Default unit: DB

Example: `CALC:UNC:ENR:UNC 0.05`
Defines an uncertainty of 0.05 dB.

Manual operation: See "ENR Uncert(ainty)" on page 70

CALCulate<n>:UNCertainty:ENR:UNCertainty:COLD <Uncertainty>

This command defines the uncertainty of a resistor.

If the noise sources during calibration and measurement are different, the command defines the uncertainty of the measurement noise source.

Suffix:
<n> 1..n

Parameters:

<Uncertainty> Cold temperature uncertainty value of the noise source.
Refer to the data sheet of the noise source to determine its uncertainty.

*RST: 0 K

Example: `CALC:UNC:ENR:UNC:COLD 10`
Defines an low temperature uncertainty of 10 K.

Manual operation: See "Temperature Uncert(ainty)" on page 70

CALCulate<n>:UNCertainty:ENR:UNCertainty:HOT <Uncertainty>

This command defines the uncertainty of a resistor.

If the noise sources during calibration and measurement are different, the command defines the uncertainty of the measurement noise source.

Suffix:

<n> 1..n

Parameters:

<Uncertainty> Hot temperature uncertainty value of the noise source.
Refer to the data sheet of the noise source to determine its uncertainty.

*RST: 0 K

Example: `CALC:UNC:ENR:UNC:HOT 10`
Defines an high temperature uncertainty of 10 K.

CALCulate<n>:UNCertainty:MATCh:DUT:IN:RL <ReturnLoss>

This command defines the return loss at the DUT input.

Suffix:

<n> 1..n

Parameters:

<ReturnLoss> *RST: 50.0 dB
Default unit: DB

Example: `CALC:UNC:MATC:DUT:IN:RL 25DB`
Defines a return loss of 25 dB.

Manual operation: See "Input / Output Match" on page 71

CALCulate<n>:UNCertainty:MATCh:DUT:IN[:VSWR] <VSWR>

This command defines the VSWR at the DUT input.

Suffix:

<n> 1..n

Parameters:
<VSWR> *RST: 1.0

Example: `CALC:UNC:MATC:DUT:IN 1.1`
Defines a VSWR of 1.1 at the DUT input.

Manual operation: See "Input / Output Match" on page 71

CALCulate<n>:UNCertainty:MATCh:DUT:OUT:RL <ReturnLoss>

This command defines the returns loss at the DUT output.

Suffix:
<n> 1..n

Parameters:
<ReturnLoss> *RST: 50.0 dB
Default unit: DB

Example: `CALC:UNC:MATC:DUT:OUT:RL 40DB`
Defines a return loss of 40 dB at the DUT output.

Manual operation: See "Input / Output Match" on page 71

CALCulate<n>:UNCertainty:MATCh:DUT:OUT[:VSWR] <VSWR>

This command defines the VSWR at the DUT output.

Suffix:
<n> 1..n

Parameters:
<VSWR> *RST: 1.0

Example: `CALC:UNC:MATC:DUT:OUT 2.0`
Defines a VSWR of 2.0 at the DUT output.

Manual operation: See "Input / Output Match" on page 71

CALCulate<n>:UNCertainty:MATCh:PREamp:RL <ReturnLoss>

This command defines the return loss at the input of the preamplifier.

Suffix:
<n> 1..n

Parameters:
<ReturnLoss> *RST: 13.98 dB
Default unit: DB

Example: `CALC:UNC:MATC:PRE:RL 14.5DB`
Defines a return loss of 14.5 dB.

CALCulate<n>:UNCertainty:MATCh:PREamp[:VSWR] <VSWR>

This command defines the VSWR at the input of the preamplifier.

The command is available if you have turned on the preamplifier with `CALCulate<n>:UNCertainty:PREamp:STATe` on page 142.

Suffix:
<n> 1..n

Parameters:
<VSWR> *RST: 1.5

Example: `CALC:UNC:MATC:PRE 1.8`
Defines a VSWR of 1.8.

CALCulate<n>:UNCertainty:MATCh:SOURce:CALibration[:VSWR] <VSWR>

This command defines the VSWR at the calibration noise source output.

This command is available when `[SENSe:]CORRection:ENR:COMMon` and `CALCulate<n>:UNCertainty:COMMon` are off.

If a smart noise source is used, the VSWR values defined in the SNS table are used.

Suffix:
<n> 1..n

Parameters:
<VSWR> *RST: 1.15

Example: `CALC:UNC:MATC:SOUR:CAL 1.4`
Defines a VSWR of 1.4.

Manual operation: See "Output Match" on page 70

CALCulate<n>:UNCertainty:MATCh:SOURce:CALibration:RL <ReturnLoss>

This command defines the return loss at the calibration noise source output.

This command is available when `[SENSe:]CORRection:ENR:COMMon` and `CALCulate<n>:UNCertainty:COMMon` are off.

If a smart noise source is used, the return loss values defined in the SNS table are used.

Suffix:
<n> 1..n

Parameters:
<ReturnLoss> *RST: 23.13 dB
Default unit: DB

Example: `CALC:UNC:MATC:SOUR:CAL:RL 20DB`
Defines a return loss of 20 dB.

Manual operation: See "Output Match" on page 70

CALCulate<n>:UNCertainty:MATCh:SOURce:RL <ReturnLoss>

This command defines the return loss at the noise source output.

If the noise sources during calibration and measurement are different, the command defines the uncertainty of the measurement noise source.

Suffix:
<n> 1..n

Parameters:
<ReturnLoss> *RST: 23.13 dB
Default unit: DB

Example: `CALC:UNC:MATC:SOUR:RL 20DB`
Defines a return loss of 20 dB.

Manual operation: See "Output Match" on page 70

CALCulate<n>:UNCertainty:MATCh:SOURce[:VSWR] <VSWR>

This command defines the VSWR at the noise source output.

If the noise sources during calibration and measurement are different, the command defines the uncertainty of the measurement noise source.

If a smart noise source is used, the VSWR values defined in the SNS table are used.

Suffix:
<n> 1..n

Parameters:
<VSWR> *RST: 1.15

Example: `CALC:UNC:MATC:SOUR 1.4`
Defines a VSWR of 1.4.

CALCulate<n>:UNCertainty:PREamp:GAIN <Gain>

This command define the "gain" of an external preamplifier that may be part of the test setup.

Suffix:
<n> 1..n

Parameters:
<Gain> **Gain of the preamplifier.**
Refer to the data sheet of the preamplifier to determine its "gain".
*RST: 20 dB
Default unit: DB

Example: `CALC:UNC:PRE:GAIN 15DB`
Defines a gain of 15 dB.

Manual operation: See "Preamplifier Gain (PA Gain)" on page 72

CALCulate<n>:UNCertainty:PREamp:NOISe <NoiseLevel>

This command defines the noise level of an external preamplifier that may be part of the test setup.

Suffix:
<n> 1..n

Parameters:
<NoiseLevel> Noise level of the preamplifier.
Refer to the data sheet of the preamplfier to determine its noise level.

*RST: 5 dB
Default unit: DB

Example: `CALC:UNC:PRE:NOIS 10DB`
Defines a noise level of 10 dB.

Manual operation: See "Preamplifier noise figure (PA NF)" on page 72

CALCulate<n>:UNCertainty:PREamp:STATe <State>

This command includes or excludes an external preamplifier from the uncertainty calculation.

If the test setup uses an external preamplifier, you also have to define its "noise figure" and "gain" values.

Suffix:
<n> 1..n

Parameters:
<State> ON | OFF | 1 | 0

*RST: 0

Example: `CALC:UNC:PRE:STAT ON`
Turns the preamplifier on.

Manual operation: See "External Preamplifier (Ext PA)" on page 72

CALCulate<n>:UNCertainty[:RESult]?

This command queries the uncertainty of "noise figure" results.

Suffix:
<n> 1..n

Return values:
<Uncertainty> Measurement uncertainty in dB.

Example: `CALC:UNC?`
Queries the uncertainty.

Usage: Query only

Manual operation: See "Use Measurement Values" on page 71

CALCulate<n>:UNCertainty:SANalyzer:GAIN:UNCertainty? <Uncertainty>

This command queries the uncertainty value of the spectrum analyzer's internal "gain".

Suffix:
<n> 1..n

Query parameters:
<Uncertainty> "Gain" uncertainty of the spectrum analyzer in dB.
Default unit: DB

Example: `CALC:UNC:SAN:GAIN:UNC?`
Queries the "gain" uncertainty.

CALCulate<n>:UNCertainty:SANalyzer:NOISe:UNCertainty? <Uncertainty>

This command queries the uncertainty value of the spectrum analyzer's internal noise.

Suffix:
<n> 1..n

Query parameters:
<Uncertainty> "Noise figure" uncertainty of the spectrum analyzer in dB.
Default unit: DB

Example: `CALC:UNC:SAN:NOIS:UNC?`
Queries the "noise figure" uncertainty.

7.13 Performing measurements

The following commands are necessary to perform "noise figure" measurements.

Example: perform calibration and subsequent single sweep measurement

```
//Perform calibration:
CONF:CORR
INIT;*OPC?
//Perform single sweep measurement and use 2nd stage correction:
CORR:STAT ON
CONF:LIST:SING
INIT
```

You can also perform a sequence of measurements using the Sequencer (see "Multiple Channel Setups and Sequencer Function" on page 12).

ABORt 144
INITiate<n>:CONTinuous 144
INITiate<n>[:IMMediate] 145
INITiate:SEQuencer:ABORt 145
INITiate:SEQuencer:IMMediate 145
INITiate:SEQuencer:MODE 146
[SENSe:]CONFigure:CONTrol 146
[SENSe:]CONFigure:MEASurement 146
SYSTem:SEQuencer 147

ABORt

This command aborts the measurement in the current channel setup and resets the trigger system.

To prevent overlapping execution of the subsequent command before the measurement has been aborted successfully, use the `*OPC?` or `*WAI` command after `ABOR` and before the next command.

For details on overlapping execution see Remote control via SCPI.

Note on blocked remote control programs:

If a sequential command cannot be completed, for example because a triggered sweep never receives a trigger, the remote control program will never finish and the remote channel to the R&S ZNL is blocked for further commands. In this case, you must interrupt processing on the remote channel first in order to abort the measurement.

To do so, send a "Device Clear" command from the control instrument to the R&S ZNL on a parallel channel to clear all currently active remote channels. Depending on the used interface and protocol, send the following commands:

- **Visa**: `viClear()`

Now you can send the `ABORt` command on the remote channel performing the measurement.

Example: `ABOR;:INIT:IMM`
Aborts the current measurement and immediately starts a new one.

Example:
```
ABOR;*WAI
INIT:IMM
```
Aborts the current measurement and starts a new one once abortion has been completed.

Usage: Event

INITiate<n>:CONTinuous <State>

This command controls the sweep mode for an individual channel setup.

Note that in single sweep mode, you can synchronize to the end of the measurement with *OPC, *OPC? or *WAI. In continuous sweep mode, synchronization to the end of the measurement is not possible. Thus, it is not recommended that you use continuous sweep mode in remote control, as results like trace data or markers are only valid after a single sweep end synchronization.

For details on synchronization see Remote control via SCPI.

Example: `INIT:CONT OFF`
Switches the sweep mode to single sweep.
`INIT:CONT ON`
Switches the sweep mode to continuous sweep.

Manual operation: See " Continuous Sweep / Run Cont " on page 74

INITiate<n>[:IMMediate]

This command starts a (single) new measurement.

You can synchronize to the end of the measurement with *OPC, *OPC? or *WAI.

For details on synchronization see Remote control via SCPI.

Suffix:
<n> irrelevant

Manual operation: See "Tuning Mode" on page 44
See "Single Sweep / Run Single " on page 74
See "Calibrate" on page 75

INITiate:SEQuencer:ABORt

This command stops the currently active sequence of measurements.

You can start a new sequence any time using `INITiate:SEQuencer:IMMediate` on page 145.

Usage: Event

INITiate:SEQuencer:IMMediate

This command starts a new sequence of measurements by the Sequencer.

Before this command can be executed, the Sequencer must be activated (see `SYSTem:SEQuencer` on page 147).

Example: `SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single sequence mode so each active measurement is performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.

INITiate:SEQuencer:MODE <Mode>

Defines the capture mode for the entire measurement sequence and all measurement groups and channels it contains.

Note: To synchronize to the end of a measurement sequence using `*OPC`, `*OPC?` or `*WAI`, use `SINGle` Sequencer mode.

Parameters:

<Mode>

SINGle
Each measurement group is started one after the other in the order of definition. All measurement channels in a group are started simultaneously and performed once. After *all* measurements are completed, the next group is started. After the last group, the measurement sequence is finished.

CONTinuous
Each measurement group is started one after the other in the order of definition. All measurement channels in a group are started simultaneously and performed once. After *all* measurements are completed, the next group is started. After the last group, the measurement sequence restarts with the first one and continues until it is stopped explicitly.

*RST: CONTinuous

[SENSe:]CONFigure:CONTrol <Mode>

This command selects the measurement mode for the hot and cold power measurements.

Note that selecting a noise source with resistor characteristics with `[SENSe:]CORRection:ENR:CALibration:TYPE` or `[SENSe:]CORRection:ENR[:MEASurement]:TYPE` automatically selects manual measurement mode.

Parameters:

<Mode> AUTO | MANual

AUTO
Performs the Power (Hot) and Power (Cold) measurement in one step.

MANual
Performs the Power (Hot) and Power (Cold) measurement in two separate steps.

Example: `CONF:CONT AUTO`
Selects the automatic measurement mode.

Manual operation: See "Meas Mode (Auto Manual)" on page 75

[SENSe:]CONFigure:MEASurement <Measurement>

This command selects the type of power measurement to perform next.

The command is available for manual measurements (see [SENSe:]CONFigure:CONTrol).

Parameters:

<Measurement> HOT | COLD

COLD
Performs the Power (Cold) measurement next.

HOT
Performs the Power (Hot) measurement next.

Example:
```
CONF:CONT MAN
CONF:MEAS HOT
```
Performs the hot power measurement.

Manual operation: See "Meas Mode (Auto Manual)" on page 75

SYSTem:SEQuencer <State>

This command turns the Sequencer on and off. The Sequencer must be active before any other Sequencer commands (INIT:SEQ...) are executed, otherwise an error occurs.

A detailed programming example is provided in the "Operating Modes" chapter in the R&S ZNL User Manual.

Parameters:

<State> ON | OFF | 0 | 1

ON | 1
The Sequencer is activated and a sequential measurement is started immediately.

OFF | 0
The Sequencer is deactivated. Any running sequential measurements are stopped. Further Sequencer commands (INIT:SEQ...) are not available.

*RST: 0

Example:
```
SYST:SEQ ON
```
Activates the Sequencer.
```
INIT:SEQ:MODE SING
```
Sets single Sequencer mode so each active measurement is performed once.
```
INIT:SEQ:IMM
```
Starts the sequential measurements.
```
SYST:SEQ OFF
```

7.14 Configuring the inputs and outputs

- Impedance 148

7.14.1 Impedance

INPut<ip>:IMPedance <Impedance>

This command selects the nominal input impedance of the RF input. In some applications, only 50 Ω are supported.

Suffix:
<ip> 1 | 2
irrelevant

Parameters:
<Impedance> 50 | 75
*RST: 50 Ω
Default unit: OHM

Example: `INP:IMP 75`

Manual operation: See " Impedance " on page 76

7.15 Configuring the display

The following commands are necessary to configure and scale the result displays.

DISPlay[:WINDow<n>]:TABLe:ITEM 148
DISPlay[:WINDow<n>]:TRACe<t>:SYMBols 149
DISPlay[:WINDow<n>]:TRACe<t>:UNCertainty 149
DISPlay[:WINDow<n>]:TRACe<t>:X[:SCALe] 149
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:BOTTom 150
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO 151
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:TOP 151

DISPlay[:WINDow<n>]:TABLe:ITEM <Items>, <State>

This command selects the items displayed in the Result Table.

Suffix:
<n> 1..n
Window

Parameters:
<Items> NOISe | GAIN | TEMPerature | YFACtor | ENR | PHOT | PCOLd | CYFactor | CPHot | CPCold | NUNCertainty
For a list of possible parameter values (table items) see the parameter description of the `TRACe<n>[:DATA]?` command.

<State> ON | OFF | 1 | 0

Example: `DISP:WIND2:TABL:ITEM NOIS,OFF`
Removes the Noise result from the Result Table.

Manual operation: See "Result Table" on page 22

DISPlay[:WINDow<n>]:TRACe<t>:SYMBols <State>

This command turns symbols that represent the measurement points on a trace on and off.

Suffix:
<n> 1..n
Window

<t> 1..n

Parameters:
<State> ON | OFF | 1 | 0
*RST: 0

Example: `DISP:WIND2:TRAC:SYMB ON`
Switches on the display of symbols in window 2..

Manual operation: See "Symbols" on page 79

DISPlay[:WINDow<n>]:TRACe<t>:UNCertainty <State>

If enabled, an additional trace is displayed indicating the measured trace values ± the uncertainty values determined by the uncertainty calculator. This result is only useful for "noise figure" measurements.

Suffix:
<n> 1..n
Window

<t> 1..n
Trace

Parameters:
<State> ON | OFF | 0 | 1
OFF | 0
Switches the function off
ON | 1
Switches the function on
*RST: 0

Example: `DISP:WIND:TRAC:UNC ON`

DISPlay[:WINDow<n>]:TRACe<t>:X[:SCALe] <Frequency>

This command selects the type of frequency displayed on the x-axis.

Suffix:
<n> 1..n
Window

<t> 1..n

Parameters:

<Frequency> RF | IF | LO

IF
Intermediary frequency, e.g. for measurements on frequency converting DUTs.

RF
Radio frequency.

*RST: RF

Example: `CONF:MODE:DUT DOWN`
The DUT converts the input frequency to a lower output frequency.
`DISP:TRAC:X RF`
Shows the RF frequency on the x-axis.

Manual operation: See "X-Axis" on page 79

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:BOTTom <Level>

This command defines the bottom value of the y-axis.

Suffix:

<n> 1..n
Window

<t> 1..n
Trace

Parameters:

<Level> The value ranges depend on the result display.

Noise figure
-75 dB to 75 dB

Noise temperature
-999990000 K to 999990000 K

Y-factor
-200 dB to 200 dB

Gain
-75 dB to 75 dB

Power (hot)
-200 dBm to 200 dBm

Power (cold)
-200 dBm to 200 dBm

Default unit: DB

Example:
```
DISP:WIND2:TRAC:Y:SCAL:AUTO OFF
DISP:WIND2:TRAC:Y:BOTT
```

Manual operation: See "Auto Scale / Min / Max" on page 78

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO <State>

This command turns automatic scaling of the y-axis on and off.

Suffix:
<n> 1..n
Window

<t> 1..n

Parameters:
<State> ON | OFF | 1 | 0
*RST: 1

Example: `DISP:WIND2:TRAC:Y:AUTO ON`
Turns on automatic scaling for measurement window 2.

Manual operation: See "Auto Scale / Min / Max" on page 78

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:TOP <Level>

This command defines the top value of the y-axis.

Suffix:
<n> 1..n
Window

<t> 1..n
Trace

Parameters:
<Level> The value ranges depend on the result display.

Noise figure
-75 dB to 75 dB

Noise temperature
-999990000 K to 999990000 K

Y-factor
-200 dB to 200 dB

Gain
-75 dB to 75 dB

Power (hot)
-200 dBm to 200 dBm

Power (cold)
-200 dBm to 200 dBm

Default unit: DB

Example:
```
DISP:WIND2:TRAC:Y:SCAL:AUTO OFF
DISP:WIND2:TRAC:Y:TOP
```

Manual operation: See "Auto Scale / Min / Max" on page 78

7.16 Working with traces

The following commands are necessary to define trace characteristics.

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE 152
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>[:STATe] 152
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing:APERture 153
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing[:STATe] 153
FORMat[:DATA] 154
FORMat:DEXPort:DSEParator 154
FORMat:DEXPort:HEADer 155
FORMat:DEXPort:TRACes 155
MMEMory:STORe<n>:TRACe 155
TRACe<n>:COPY 156

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE <Mode>

This command selects the trace mode. If necessary, the selected trace is also activated.

Suffix:

<n> Window

<w> subwindow
Not supported by all applications

<t> Trace

Parameters:

<Mode> BLANk | VIEW | WRITe

*RST: Trace 1: WRITe, Trace 2-4: BLANk

Example:

```
INIT:CONT OFF
```
Switching to single sweep mode.
```
SWE:COUN 16
```
Sets the number of measurements to 16.
```
DISP:TRAC3:MODE WRIT
```
Selects clear/write mode for trace 3.
```
INIT;*WAI
```
Starts the measurement and waits for the end of the measurement.

Manual operation: See "Traces" on page 81

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>[:STATe] <State>

This command turns a trace on and off.

The measurement continues in the background.

Suffix:

<n> Window

<w> subwindow
Not supported by all applications

<t> Trace

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `DISP:TRAC3 ON`

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing:APERture <Aperture>

This command defines the degree (aperture) of the trace smoothing, if `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing[:STATe]TRUE`.

Suffix:

<n> Window

<w> subwindow

<t> Trace

Parameters:

<Aperture> Range: 1 to 50
*RST: 2
Default unit: PCT

Example: `DISP3:TRAC2:SMO:APER 5`
Defines an aperture of 5% for trace 2 in window 3

Manual operation: See "Smoothing" on page 82

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing[:STATe] <State>

This command turns trace smoothing for a particular trace on and off.

If enabled, the trace is smoothed by the value specified using `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing:APERture` on page 153.

Suffix:

<n> Window

<w> subwindow

<t> Trace

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `DISP3:TRAC2:SMO ON`
Turns on trace smoothing for trace 2 in window 3

Manual operation: See "Smoothing" on page 82

FORMat[:DATA] <Format>[, <BitLength>]

This command selects the data format that is used for transmission of trace data from the R&S ZNL to the controlling computer.

Note that the command has no effect for data that you send to the R&S ZNL. The R&S ZNL automatically recognizes the data it receives, regardless of the format.

Parameters:

<Format>

ASCii
ASCii format, separated by commas.
This format is almost always suitable, regardless of the actual data format. However, the data is not as compact as other formats can be.

REAL
Floating-point numbers (according to IEEE 754) in the "definite length block format".
In the Spectrum application, the format setting `REAL` is used for the binary transmission of trace data.

<BitLength>

Length in bits for floating-point results

16
16-bit floating-point numbers.
Compared to `REAL,32` format, half as many numbers are returned.

32
32-bit floating-point numbers
For I/Q data, 8 bytes per sample are returned for this format setting.

64
64-bit floating-point numbers
Compared to `REAL,32` format, twice as many numbers are returned.

Example: `FORM REAL,32`

FORMat:DEXPort:DSEParator <Separator>

This command selects the decimal separator for data exported in ASCII format.

Parameters:

<Separator>

POINt | COMMa

COMMa
Uses a comma as decimal separator, e.g. *4,05*.

POINt
Uses a point as decimal separator, e.g. *4.05*.

*RST: *RST has no effect on the decimal separator. Default is POINt.

Example: `FORM:DEXP:DSEP POIN`
Sets the decimal point as separator.

Manual operation: See "Decimal Separator" on page 82

FORMat:DEXPort:HEADer <State>

If enabled, additional instrument and measurement settings are included in the header of the export file for result data. If disabled, only the pure result data from the selected traces and tables is exported.

Parameters:
<State> ON | OFF | 0 | 1
*RST: 1

Manual operation: See " Include Instrument & Measurement Settings " on page 82

FORMat:DEXPort:TRACes <Selection>

This command selects the data to be included in a data export file (see `MMEMory:STORe<n>:TRACe` on page 155).

Parameters:
<Selection> SINGle | ALL

SINGle
Only a single trace is selected for export, namely the one specified by the `MMEMory:STORe<n>:TRACe` command.

ALL
Selects all active traces and result tables (e.g. "Result Summary", marker peak list etc.) in the current application for export to an ASCII file.
The <trace> parameter for the `MMEMory:STORe<n>:TRACe` command is ignored.

*RST: SINGle

Manual operation: See " Export all Traces and all Table Results " on page 82

MMEMory:STORe<n>:TRACe <Trace>, <FileName>

This command exports trace data from the specified window to an ASCII file.

Suffix:
<n> Window

Parameters:

<Trace> Number of the trace to be stored

<FileName> String containing the path and name of the target file.

Example: `MMEM:STOR1:TRAC 1,'C:\TEST.ASC'`
Stores trace 1 from window 1 in the file `TEST.ASC`.

Manual operation: See " Export Trace to ASCII File " on page 82

TRACe<n>:COPY <TraceNumber>, <TraceNumber>

This command copies data from one trace to another.

Suffix:

<n> Window

Parameters:

<TraceNumber> **TRACE1 | TRACE2 | TRACE3 | TRACE4**
The first parameter is the destination trace, the second parameter is the source.
(Note the 'e' in the parameter is required!)

Example: `TRAC:COPY TRACE1,TRACE2`
Copies the data from trace 2 to trace 1.

Manual operation: See " Copy Trace " on page 83

7.17 Working with limit lines

The following commands are necessary to set up limit lines and checks.

When configuring limit lines for the "noise figure" application via remote control, you have to send some commands in a defined order.

1. Select the limit line you want to configure by name or create a new limit line name.
2. Select the result type you want to apply the limit line to.

   The application automatically selects the unit and scale to make the line compatible to the result type.
3. Define the horizontal data points of the limit line.
4. Define the vertical data points of the limit line. Depending on the command syntax you are using, the shape also defines if the limit line is an upper or lower limit line (`CALCulate:LIMit:UPPer:...` or `CALCulate:LIMit:LOWer:...`).

Example: Configure an upper limit line for the Noise Figure result type

```
//Select or create the limit line by name.
CALC:LIM:NAME 'NoiseFigure'
//Comment on the limit line.
```

```
CALC:LIM:COMM 'Limit line to test noise figure results'
//Select the result type (here: Noise Figure) to apply the limit line to.
CALC:LIM:TYPE NOIS
//Define the horizontal data points of the limit line.
CALC:LIM:CONT 100MHZ,850MHZ
//Shift the limit line 50 MHz to the left.
CALC:LIM:CONT:SHIF -50MHZ
//Define the vertical data points of an (upper) limit line.
//The unit is fix according to the result type you have selected.
CALC:LIM:UPP 10,10
//Shift the limit line 5 dB down.
CALC:LIM:UPP:SHIF -5
//Turn the limit line on.
CALC:LIM:UPP:STAT ON
//Select the trace to check.
CALC:LIM:TRAC 1
//Turn on the limit check.
CALC:LIM:STAT ON
//Query the limit check results.
CALC:LIM:FAIL?
```


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- Defining horizontal data points....158
- Controlling lower limit lines....159
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- Managing limit lines....162
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7.17.1 Defining general characteristics of a limit line

CALCulate<n>:LIMit<li>:COMMent....157
CALCulate<n>:LIMit<li>:NAME....157
CALCulate<n>:LIMit<li>:TYPE....158

CALCulate<n>:LIMit<li>:COMMent <Comment>

This command defines a comment for a limit line.

Suffix:

<n> irrelevant

 Limit line

Parameters:

<Comment> String containing the description of the limit line.

CALCulate<n>:LIMit<li>:NAME <Name>

This command selects a limit line that already exists or defines a name for a new limit line.

Suffix:
<n> Window
 Limit line

Parameters:
<Name> String containing the limit line name.
*RST: REM1 to REM8 for lines 1 to 8

CALCulate<n>:LIMit<li>:TYPE <Result>

This command configures a limit line for a particular result type.

Suffix:
<n> 1..n
 1..n
Limit line

Parameters:
<Result> NOISe | GAIN | TEMPerature | YFACtor | ENR | PHOT | PCOLd

GAIN
Assigns the limit line to "gain" reuslts.

NOISe
Assigns the limit line to "noise figure" results.

PCOLd
Assigns the limit line to power (cold) results.

PHOT
Assigns the limit line to power (hot) results.

TEMPerature
Assigns the limit line to "noise temperature" results.

YFACtor
Assigns the limit line to "y-factor" results.

Example: `CALC:LIM2:TYPE GAIN`
Assigns limit line 2 to the "gain" result display.

7.17.2 Defining horizontal data points

Note that the number of data points on the horizontal axis should be the same as the number of data points on the vertical axis. Otherwise the limit line may take on an unintended shape.

Example: Number of vertical data points < number of horizontal data points

```
CALC:LIM:CONT 100MHZ,200MHZ,300MHZ,400MHZ,500MHZ
CALC:LIM:UPP 0,5,0
```

⇒ the application dumps 400 and 500 MHz.

Example: Number of vertical data points > number of horizontal data points

```
CALC:LIM:CONT 100MHZ,200MHZ,300MHZ,400MHZ,500MHZ
CALC:LIM:UPP 0,5,0,5,0,5,0
```

⇒ the application adds new horizontal data points (500.00000100 MHz and 500.00000200 MHz).

CALCulate<n>:LIMit<li>:CONTrol[:DATA] 159
CALCulate<n>:LIMit<li>:CONTrol:SHIFt 159

CALCulate<n>:LIMit<li>:CONTrol[:DATA] <LimitLinePoints>

This command defines the horizontal definition points of a limit line.

Suffix:

<n> irrelevant

 Limit line

Parameters:

<LimitLinePoints> Variable number of x-axis values.
Note that the number of horizontal values has to be the same as the number of vertical values set with `CALCulate<n>:LIMit<li>:LOWer[:DATA]` or `CALCulate<n>:LIMit<li>:UPPer[:DATA]`. If not, the R&S ZNL either adds missing values or ignores surplus values.

*RST: -
Default unit: HZ

CALCulate<n>:LIMit<li>:CONTrol:SHIFt <Distance>

This command moves a complete limit line horizontally.

Compared to defining an offset, this command actually changes the limit line definition points by the value you define.

Suffix:

<n> irrelevant

 Limit line

Parameters:

<Distance> Numeric value.
The unit depends on the scale of the x-axis.

Default unit: HZ

7.17.3 Controlling lower limit lines

CALCulate<n>:LIMit<li>:LOWer[:DATA] 160
CALCulate<n>:LIMit<li>:LOWer:SHIFt 160
CALCulate<n>:LIMit<li>:LOWer:STATe 160

CALCulate<n>:LIMit<li>:LOWer[:DATA] <LimitLinePoints>

This command defines the vertical definition points of a lower limit line.

Suffix:
<n> irrelevant

 Limit line

Parameters:
<LimitLinePoints> Variable number of level values.
Note that the number of vertical values has to be the same as the number of horizontal values set with `CALCulate<n>:LIMit<li>:CONTrol[:DATA]`. If not, the R&S ZNL either adds missing values or ignores surplus values.

*RST: Limit line state is OFF
Default unit: DBM

CALCulate<n>:LIMit<li>:LOWer:SHIFt <Distance>

This command moves a complete lower limit line vertically.

Compared to defining an offset, this command actually changes the limit line definition points by the value you define.

Suffix:
<n> Window

 Limit line

Parameters:
<Distance> Defines the distance that the limit line moves.

Default unit: DB

CALCulate<n>:LIMit<li>:LOWer:STATe <State>

This command turns a lower limit line on and off.

Before you can use the command, you have to select a limit line with `CALCulate<n>:LIMit<li>:NAME` on page 157.

Suffix:
<n> irrelevant

 Limit line

Parameters:
<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

7.17.4 Controlling upper limit lines

CALCulate<n>:LIMit<li>:UPPer[:DATA] 161
CALCulate<n>:LIMit<li>:UPPer:SHIFt 161
CALCulate<n>:LIMit<li>:UPPer:STATe 161

CALCulate<n>:LIMit<li>:UPPer[:DATA] <LimitLinePoints>

This command defines the vertical definition points of an upper limit line.

Suffix:
<n> irrelevant

 Limit line

Parameters:
<LimitLinePoints> Variable number of level values.
Note that the number of vertical values has to be the same as the number of horizontal values set with `CALCulate<n>:LIMit<li>:CONTrol[:DATA]`. If not, the R&S ZNL either adds missing values or ignores surplus values.

*RST: Limit line state is OFF
Default unit: DBM

CALCulate<n>:LIMit<li>:UPPer:SHIFt <Distance>

This command moves a complete upper limit line vertically.

Compared to defining an offset, this command actually changes the limit line definition points by the value you define.

Suffix:
<n> irrelevant

 Limit line

Parameters:
<Distance> Defines the distance that the limit line moves.

CALCulate<n>:LIMit<li>:UPPer:STATe <State>

This command turns an upper limit line on and off.

Before you can use the command, you have to select a limit line with `CALCulate<n>:LIMit<li>:NAME` on page 157.

Suffix:
<n> irrelevant

 Limit line

Parameters:
<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

7.17.5 Managing limit lines

CALCulate<n>:LIMit<li>:ACTive? 162
CALCulate<n>:LIMit<li>:COPY 162
CALCulate<n>:LIMit<li>:DELete 162

CALCulate<n>:LIMit<li>:ACTive?

This command queries the names of *all* active limit lines.

Suffix:
<n> irrelevant

 irrelevant

Return values:
<LimitLines> String containing the names of all active limit lines in alphabetical order.

Example: `CALC:LIM:ACT?`
Queries the names of all active limit lines.

Usage: Query only

CALCulate<n>:LIMit<li>:COPY <Line>

This command copies a limit line.

Suffix:
<n> Window

 Limit line

Parameters:
<Line> **1 to 8**
number of the new limit line

<name>
String containing the name of the limit line.

Example: `CALC:LIM1:COPY 2`
Copies limit line 1 to line 2.
`CALC:LIM1:COPY 'FM2'`
Copies limit line 1 to a new line named FM2.

CALCulate<n>:LIMit<li>:DELete

This command deletes a limit line.

Suffix:
<n> Window
 Limit line

7.17.6 Controlling limit checks

CALCulate<n>:LIMit<li>:CLEar[:IMMediate] 163
CALCulate<n>:LIMit<li>:FAIL? 163
CALCulate<n>:LIMit<li>:STATe 164
CALCulate<n>:LIMit<li>:TRACe<t> 164
CALCulate<n>:LIMit<li>:TRACe<t>:CHECk 164

CALCulate<n>:LIMit<li>:CLEar[:IMMediate]

This command deletes the result of the current limit check.

The command works on *all* limit lines in *all* measurement windows at the same time.

Suffix:
<n> Window
 irrelevant

Example: `CALC:LIM:CLE`
Deletes the result of the limit check.

CALCulate<n>:LIMit<li>:FAIL?

This command queries the result of a limit check in the specified window.

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single sweep mode.

See also `INITiate<n>:CONTinuous` on page 144.

Suffix:
<n> Window
 Limit line

Return values:
<Result> **0**
PASS
1
FAIL

Example: `INIT;*WAI`
Starts a new sweep and waits for its end.
`CALC2:LIM3:FAIL?`
Queries the result of the check for limit line 3 in window 2.

Usage: Query only

CALCulate<n>:LIMit<li>:STATe <State>

This command turns the limit check for a specific limit line on and off.

To query the limit check result, use `CALCulate<n>:LIMit<li>:FAIL?`.

Note that a new command exists to activate the limit check and define the trace to be checked in one step (see `CALCulate<n>:LIMit<li>:TRACe<t>:CHECk` on page 164).

Suffix:

<n> irrelevant

 Limit line

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:LIM:STAT ON`
Switches on the limit check for limit line 1.

CALCulate<n>:LIMit<li>:TRACe<t> <TraceNumber>

This command links a limit line to one or more traces.

Note that this command is maintained for compatibility reasons only. Limit lines no longer need to be assigned to a trace explicitly. The trace to be checked can be defined directly (as a suffix) in the new command to activate the limit check (see `CALCulate<n>:LIMit<li>:TRACe<t>:CHECk` on page 164).

Suffix:

<n> Window

 Limit line

<t> irrelevant

Parameters:

<TraceNumber> 1 to 4

*RST: 1

Example: `CALC:LIM2:TRAC 3`
Assigns limit line 2 to trace 3.

CALCulate<n>:LIMit<li>:TRACe<t>:CHECk <State>

This command turns the limit check for a specific trace on and off.

To query the limit check result, use `CALCulate<n>:LIMit<li>:FAIL?`.

Suffix:
<n> Window
 Limit line
<t> Trace

Parameters:
<State> ON | OFF | 0 | 1
OFF | 0
Switches the function off
ON | 1
Switches the function on

Example: `CALC:LIM3:TRAC2:CHEC ON`
Switches on the limit check for limit line 3 on trace 2.

7.18 Working with markers

The following commands are necessary to work with markers.

- Using markers 165
- Using delta markers 168
- Configuring markers 171
- Positioning markers 171
- Positioning delta markers 174

7.18.1 Using markers

Note that the suffix at `CALCulate` has an effect only if you query the characteristics of a marker. If you set a marker, you can ignore the suffix because the markers are linked to each other over all measurement windows and will always be on the same frequency.

CALCulate<n>:MARKer<m>:AOFF 165
CALCulate<n>:MARKer<m>[:STATe] 166
CALCulate<n>:MARKer<m>:TRACe 166
CALCulate<n>:MARKer<m>:X 166
CALCulate<n>:MARKer<m>:Y? 167

CALCulate<n>:MARKer<m>:AOFF

This command turns off all markers.

Suffix:
<n> Window
<m> Marker

Example: `CALC:MARK:AOFF`
Switches off all markers.

Manual operation: See " All Markers Off " on page 85

CALCulate<n>:MARKer<m>[:STATe] <State>

This command turns markers on and off. If the corresponding marker number is currently active as a delta marker, it is turned into a normal marker.

Suffix:
<n> Window

<m> Marker

Parameters:
<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:MARK3 ON`
Switches on marker 3.

Manual operation: See " Marker Type " on page 85

CALCulate<n>:MARKer<m>:TRACe <Trace>

This command selects the trace the marker is positioned on.

Note that the corresponding trace must have a trace mode other than "Blank".

If necessary, the command activates the marker first.

Suffix:
<n> Window

<m> Marker

Parameters:
<Trace> **1 to 4**
Trace number the marker is assigned to.

Example: //Assign marker to trace 1
`CALC:MARK3:TRAC 2`

CALCulate<n>:MARKer<m>:X <Position>

This command moves a marker to a specific coordinate on the x-axis.

If necessary, the command activates the marker.

If the marker has been used as a delta marker, the command turns it into a normal marker.

Note that markers have to be positioned on a discrete frequency that is part of the frequency list. If you set the marker on a frequency not included in the frequency list, the application positions the marker to the nearest frequency in the list (rounding up or down).

Suffix:

<n> Window

<m> Marker

Parameters:

<Position> Numeric value that defines the marker position on the x-axis. The unit depends on the result display.

Range: The range depends on the current x-axis range.
Default unit: Hz

Example: `CALC:MARK2:X 1.7MHz`
Positions marker 2 to frequency 1.7 MHz.

CALCulate<n>:MARKer<m>:Y? <Result>

Queries the result at the position of the specified marker.

Suffix:

<n> 1..n

<m> 1..n

Query parameters:

<Result> Selects the result.

CPCold
Queries calibration power (cold) results.

CPHot
Queries calibration power (hot) results.

CYFactor
Queries calibration "y-factor" results.

GAIN
Queries "gain" results.

NOISe
Queries "noise figure" results.

NUNCertainty
Queries the "noise figure" uncertainty results.

PCOLd
Queries power (cold) results.

PHOT
Queries power (hot) results.

TEMPerature
Queries "noise temperature" results.

YFACtor
Queries "y-factor" results.

Return values:
<Result> Default unit: DBM

Usage: Query only

Manual operation: See "Marker Table" on page 23

7.18.2 Using delta markers

Note that the suffix at `CALCulate` has an effect only if you query the characteristics of a marker. If you set a marker, you can ignore the suffix because the markers are linked to each other over all measurement windows and will always be on the same frequency.

CALCulate<n>:DELTamarker<m>:AOFF 168
CALCulate<n>:DELTamarker<m>:MREFerence 168
CALCulate<n>:DELTamarker<m>[:STATe] 169
CALCulate<n>:DELTamarker<m>:TRACe 169
CALCulate<n>:DELTamarker<m>:X 169
CALCulate<n>:DELTamarker<m>:Y? 170

CALCulate<n>:DELTamarker<m>:AOFF

This command turns off *all* delta markers.

Suffix:
<n> Window

<m> irrelevant

Example: `CALC:DELT:AOFF`
Turns off all delta markers.

CALCulate<n>:DELTamarker<m>:MREFerence <Reference>

This command selects a reference marker for a delta marker other than marker 1.

The reference may be another marker or the fixed reference.

Suffix:
<n> Window

<m> Marker

Parameters:
<Reference> **1 to 16**
Selects markers 1 to 16 as the reference.

FIXed
Selects the fixed reference as the reference.

Example: `CALC:DELT3:MREF 2`
Specifies that the values of delta marker 3 are relative to marker 2.

CALCulate<n>:DELTamarker<m>[:STATe] <State>

This command turns delta markers on and off.

If necessary, the command activates the delta marker first.

No suffix at DELTamarker turns on delta marker 1.

Suffix:
<n> Window

<m> Marker

Parameters:
<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:DELT2 ON`
Turns on delta marker 2.

Manual operation: See " Marker Type " on page 85

CALCulate<n>:DELTamarker<m>:TRACe <Trace>

This command selects the trace a delta marker is positioned on.

Note that the corresponding trace must have a trace mode other than "Blank".

If necessary, the command activates the marker first.

Suffix:
<n> Window

<m> Marker

Parameters:
<Trace> Trace number the marker is assigned to.

Example: `CALC:DELT2:TRAC 2`
Positions delta marker 2 on trace 2.

CALCulate<n>:DELTamarker<m>:X <Position>

This command moves a delta marker to a particular coordinate on the x-axis.

If necessary, the command activates the delta marker and positions a reference marker to the peak power.

Suffix:
<n> Window

<m> Marker

Parameters:

<Position> Numeric value that defines the marker position on the x-axis.

Range: The value range and unit depend on the measurement and scale of the x-axis.

Example: `CALC:DELT:X?`
Outputs the absolute x-value of delta marker 1.

CALCulate<n>:DELTamarker<m>:Y? <Trace>

Queries the result at the position of the specified delta marker.

Suffix:

<n> 1..n

<m> 1..n

Parameters:

<Trace>

CPCold
Queries calibration power (cold) results.

CPHot
Queries calibration power (hot) results.

CYFactor
Queries calibration "y-factor" results.

GAIN
Queries "gain" results.

NOISe
Queries "noise figure" results.

PCOLd
Queries power (cold) results.

PHOT
Queries power (hot) results.

TEMPerature
Queries "noise temperature" results.

YFACtor
Queries "y-factor" results.

Return values:

<Result> Result at the position of the delta marker.
The unit is variable and depends on the one you have currently set.

Default unit: DBM

Usage: Query only

Manual operation: See "Marker Table" on page 23

7.18.3 Configuring markers

DISPlay[:WINDow<n>]:MINFo[:STATe] 171
DISPlay[:WINDow<n>]:MTABle 171

DISPlay[:WINDow<n>]:MINFo[:STATe] <State>

This command turns the marker information in all diagrams on and off.

Suffix:
<n> irrelevant

Parameters:
<State> **ON | 1**
Displays the marker information in the diagrams.
OFF | 0
Hides the marker information in the diagrams.
*RST: 1

Example: `DISP:MINF OFF`
Hides the marker information.

Manual operation: See " Marker Info " on page 86

DISPlay[:WINDow<n>]:MTABle <DisplayMode>

This command turns the marker table on and off.

Suffix:
<n> irrelevant

Parameters:
<DisplayMode> **ON | 1**
Turns on the marker table.
OFF | 0
Turns off the marker table.
AUTO
Turns on the marker table if 3 or more markers are active.
*RST: AUTO

Example: `DISP:MTAB ON`
Activates the marker table.

Manual operation: See " Marker Table Display " on page 85

7.18.4 Positioning markers

If you are using more than one window, the application performs the peak search in the window that you have selected with the suffix at `CALCulate` only. Because the markers are linked, the frequency position of the marker in the other windows is adjusted accordingly, even if it means that the marker is on a peak in the selected window only.

CALCulate<n>:MARKer<m>:MAXimum:LEFT 172
CALCulate<n>:MARKer<m>:MAXimum:NEXT 172
CALCulate<n>:MARKer<m>:MAXimum[:PEAK] 172
CALCulate<n>:MARKer<m>:MAXimum:RIGHt 172
CALCulate<n>:MARKer<m>:MINimum:NEXT 173
CALCulate<n>:MARKer<m>:MINimum:LEFT 173
CALCulate<n>:MARKer<m>:MINimum[:PEAK] 173
CALCulate<n>:MARKer<m>:MINimum:RIGHt 173

CALCulate<n>:MARKer<m>:MAXimum:LEFT

This command moves a marker to the next positive peak.

The search includes only measurement values to the left of the current marker position.

Suffix:
<n> Window

<m> Marker

Manual operation: See " Search Next Peak " on page 87

CALCulate<n>:MARKer<m>:MAXimum:NEXT

This command moves a marker to the next positive peak.

Suffix:
<n> Window

<m> Marker

Manual operation: See " Search Next Peak " on page 87

CALCulate<n>:MARKer<m>:MAXimum[:PEAK]

This command moves a marker to the highest level.

If the marker is not yet active, the command first activates the marker.

Suffix:
<n> Window

<m> Marker

Manual operation: See " Peak Search " on page 87

CALCulate<n>:MARKer<m>:MAXimum:RIGHt

This command moves a marker to the next positive peak.

The search includes only measurement values to the right of the current marker position.

Suffix:
<n> Window
<m> Marker

Manual operation: See " Search Next Peak " on page 87

CALCulate<n>:MARKer<m>:MINimum:NEXT

This command moves a marker to the next minimum peak value.

Suffix:
<n> Window
<m> Marker

Manual operation: See " Search Next Minimum " on page 87

CALCulate<n>:MARKer<m>:MINimum:LEFT

This command moves a marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:
<n> Window
<m> Marker

Manual operation: See " Search Next Minimum " on page 87

CALCulate<n>:MARKer<m>:MINimum[:PEAK]

This command moves a marker to the minimum level.

If the marker is not yet active, the command first activates the marker.

Suffix:
<n> Window
<m> Marker

Manual operation: See " Search Minimum " on page 87

CALCulate<n>:MARKer<m>:MINimum:RIGHt

This command moves a marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:
<n> Window
<m> Marker

Manual operation: See " Search Next Minimum " on page 87

7.18.5 Positioning delta markers

If you are using more than one window, the application performs the peak search in the window that you have selected with the suffix at `CALCulate` only. Because the markers are linked, the frequency position of the marker in the other windows is adjusted accordingly, even if it means that the marker is on a peak in the selected window only.

CALCulate<n>:DELTamarker<m>:MAXimum:LEFT 174
CALCulate<n>:DELTamarker<m>:MAXimum:NEXT 174
CALCulate<n>:DELTamarker<m>:MAXimum[:PEAK] 174
CALCulate<n>:DELTamarker<m>:MAXimum:RIGHt 175
CALCulate<n>:DELTamarker<m>:MINimum:LEFT 175
CALCulate<n>:DELTamarker<m>:MINimum:NEXT 175
CALCulate<n>:DELTamarker<m>:MINimum[:PEAK] 175
CALCulate<n>:DELTamarker<m>:MINimum:RIGHt 176

CALCulate<n>:DELTamarker<m>:MAXimum:LEFT

This command moves a delta marker to the next positive peak value.

The search includes only measurement values to the left of the current marker position.

Suffix:
<n> Window

<m> Marker

Manual operation: See " Search Next Peak " on page 87

CALCulate<n>:DELTamarker<m>:MAXimum:NEXT

This command moves a marker to the next positive peak value.

Suffix:
<n> 1..n
Window

<m> 1..n
Marker

Manual operation: See " Search Next Peak " on page 87

CALCulate<n>:DELTamarker<m>:MAXimum[:PEAK]

This command moves a delta marker to the highest level.

If the marker is not yet active, the command first activates the marker.

Suffix:
<n> Window

<m> Marker

Manual operation: See " Peak Search " on page 87

CALCulate<n>:DELTamarker<m>:MAXimum:RIGHt

This command moves a delta marker to the next positive peak value on the trace.

The search includes only measurement values to the right of the current marker position.

Suffix:
<n> Window

<m> Marker

Manual operation: See " Search Next Peak " on page 87

CALCulate<n>:DELTamarker<m>:MINimum:LEFT

This command moves a delta marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:
<n> Window

<m> Marker

Manual operation: See " Search Next Minimum " on page 87

CALCulate<n>:DELTamarker<m>:MINimum:NEXT

This command moves a marker to the next minimum peak value.

Suffix:
<n> Window

<m> Marker

Manual operation: See " Search Next Minimum " on page 87

CALCulate<n>:DELTamarker<m>:MINimum[:PEAK]

This command moves a delta marker to the minimum level.

If the marker is not yet active, the command first activates the marker.

Suffix:
<n> Window

<m> Marker

Manual operation: See " Search Minimum " on page 87

CALCulate<n>:DELTamarker<m>:MINimum:RIGHt

This command moves a delta marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:
<n> Window

<m> Marker

Manual operation: See " Search Next Minimum " on page 87

7.19 Using the status register

The status reporting system stores information about the current state of the R&S ZNL. This includes, for example, information about errors during operation or information about limit checks. The R&S ZNL stores this information in the status registers and in the error queue. You can query the status register and error queue via IEC bus.

The R&S FPL1-K30 features several status registers that are specific to "noise figure" measurements. This chapter describes the application-specific registers, including the corresponding remote commands.

- Status registers for noise figure measurements.....176

7.19.1 Status registers for noise figure measurements

The figure below shows the status registers of the "noise figure" application.

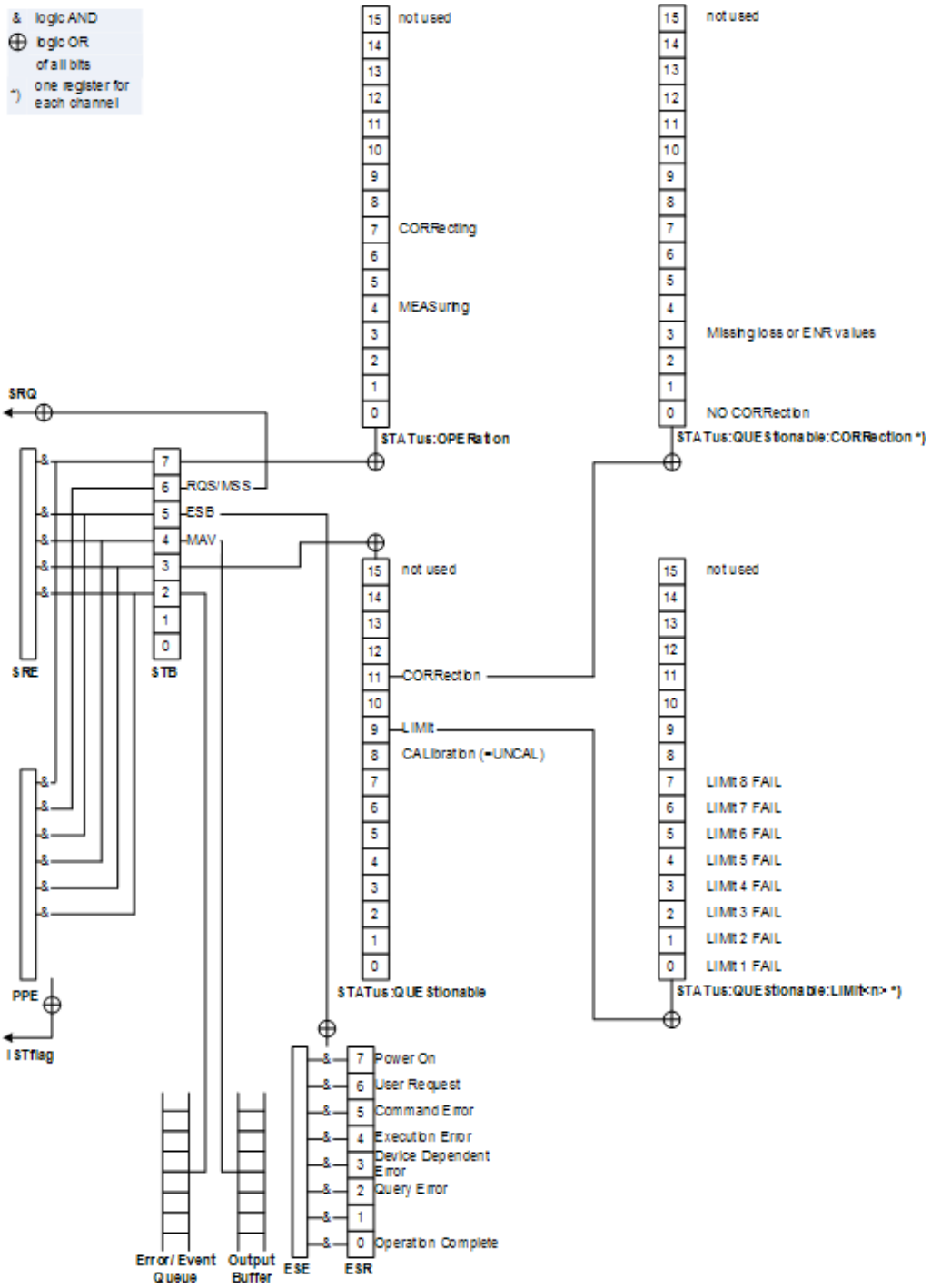

Figure 7-2: Status registers for noise figure measurements

The R&S ZNL structures the information hierarchically, with the Status Byte register (STB) and the Service Request Enable mask register (SRE) being on the highest level. The STB gets its information from the standard Event Status Register (ESR) and the Event Status Enable mask register (ESE). The STB and ESR are both defined by IEEE 488.2. In addition to the ESR, the STB also gets information from the STATus:OPERation and STATus:QUEStionable registers. These registers are the link to the lower lev-

els of the status register and are defined by SCPI. They contain information about the state of the instrument.

For a more comprehensive description of the status registers not mentioned here, and status register functionality in general, see the manual of the base unit.

7.19.1.1 STATus:OPERation register

The `STATus:OPERation` register contains information on current activities of the R&S ZNL. It also contains information on activities that have been executed since the last read out.

Bit no	Meaning
0 to 3	Unavailable for "noise figure" measurements.
4	MEASuring This bit is set if a measurement is in progress.
5 to 6	Unavailable for "noise figure" measurements.
7	CORRecting This bit is set if a 2nd stage correction is in progress.
8	HCOPy This bit is set if a hardcopy is created.
9 - 14	Unavailable for "noise figure" measurements.
15	This bit is always 0.

7.19.1.2 STATus:QUEStionable register

The `STATus:QUEStionable` register contains information about indefinite states which can occur if the unit is operated without meeting the specifications.

Bit no	Meaning
0 to 7	Unavailable for "noise figure" measurements.
8	CALibration This bit is set if the R&S ZNL is not calibrated.
9	LIMit This bit is set if a limit line is violated.
10	Unavailable for "noise figure" measurements.
11	CORRection This bit is set if the "noise figure" calibration is questionable.
14	Unavailable for "noise figure" measurements.
15	This bit is always 0.

7.19.1.3 STATus:QUEStionable:LIMit register

The `STATus:QUEStionable:LIMit` register contains information about limit lines and the results of a limit checks.

The number of LIMit registers depends on the number of measurement windows available in any application.

Bit no	Meaning
0	LIMit 1 FAIL This bit is set if limit line 1 is violated.
1	LIMit 2 FAIL This bit is set if limit line 2 is violated.
2	LIMit 3 FAIL This bit is set if limit line 3 is violated.
3	LIMit 4 FAIL This bit is set if limit line 4 is violated.
4	LIMit 5 FAIL This bit is set if limit line 5 is violated.
5	LIMit 6 FAIL This bit is set if limit line 6 is violated.
6	LIMit 7 FAIL This bit is set if limit line 7 is violated.
7	LIMit 8 FAIL This bit is set if limit line 8 is violated.
8 to 14	Unavailable for "noise figure" measurements.
15	This bit is always 0.

7.19.1.4 STATus:QUEStionable:CORRection register

The `STATus:QUEStionable:CORRection` register contains information about the calibration status of "noise figure" measurements.

Bit no	Meaning
0	NO CORRection This bit is set if calibration is required.
1 to 2	Unavailable for "noise figure" measurements.
3	Missing Loss or ENR values This bit is set if loss or ENR values are missing for one or more measurement frequencies.

Bit no	Meaning
4 to 14	Unavailable for "noise figure" measurements.
15	This bit is always 0.

7.19.1.5 Status register remote commands

STATus:OPERation[:EVENt]?....180
STATus:QUEStionable[:EVENt]?....180
STATus:QUEStionable:CORRection[:EVENt]?....180
STATus:QUEStionable:LIMit[:EVENt]?....180
STATus:OPERation:CONDition?....180
STATus:QUEStionable:CONDition?....180
STATus:QUEStionable:CORRection:CONDition?....180
STATus:QUEStionable:LIMit:CONDition?....180
STATus:OPERation:ENABle....181
STATus:QUEStionable:ENABle....181
STATus:QUEStionable:CORRection:ENABle....181
STATus:QUEStionable:LIMit:ENABle....181
STATus:OPERation:NTRansition....181
STATus:QUEStionable:NTRansition....181
STATus:QUEStionable:CORRection:NTRansition....181
STATus:QUEStionable:LIMit:NTRansition....181
STATus:OPERation:PTRansition....181
STATus:QUEStionable:PTRansition....181
STATus:QUEStionable:CORRection:PTRansition....181
STATus:QUEStionable:LIMit:PTRansition....181

STATus:OPERation[:EVENt]?
STATus:QUEStionable[:EVENt]?
STATus:QUEStionable:CORRection[:EVENt]? <ChannelName>
STATus:QUEStionable:LIMit[:EVENt]? <ChannelName>

These commands read out the EVENt section of the status register.

The commands at the same time delete the contents of the EVENt section.

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

STATus:OPERation:CONDition?
STATus:QUEStionable:CONDition?
STATus:QUEStionable:CORRection:CONDition? <ChannelName>
STATus:QUEStionable:LIMit:CONDition? <ChannelName>

These commands read out the CONDition section of the status register.

The commands do not delete the contents of the EVENt section.

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

STATus:OPERation:ENABle <SumBit>,<ChannelName>
STATus:QUEStionable:ENABle <SumBit>,<ChannelName>
STATus:QUEStionable:CORRection:ENABle <SumBit>,<ChannelName>
STATus:QUEStionable:LIMit:ENABle <SumBit>,<ChannelName>

These commands control the ENABle part of a register.

The ENABle part allows true conditions in the EVENt part of the status register to be reported in the summary bit. If a bit is 1 in the enable register and its associated event bit transitions to true, a positive transition occurs in the summary bit reported to the next higher level.

Parameters:

<SumBit> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

STATus:OPERation:NTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:NTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:CORRection:NTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:LIMit:NTRansition <SumBit>,<ChannelName>

These commands control the Negative TRansition part of a register.

Setting a bit causes a 1 to 0 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Parameters:

<SumBit> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

STATus:OPERation:PTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:PTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:CORRection:PTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:LIMit:PTRansition <SumBit>,<ChannelName>

These commands control the Positive TRansition part of a register.

Setting a bit causes a 0 to 1 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Parameters:

<SumBit> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

7.20 Deprecated remote commands for noise figure measurements

Following is a list of deprecated remote commands. The remote commands are still supported to maintain compatibility to previous versions of "noise figure" measurements (like the R&S FSV-K30), but it is strongly recommended to use the command system in the way it is meant to be used in the R&S FPL1-K30.

Legacy command	Replaced by	Comment
`CALCulate:LIMit:TRACe`	`CALCulate:LIMit:TYPE`	Parameters `NFIGure`, `TEFFective` and `GAIN` were supported to assign a limit line to a result and thus the trace because trace and result type were fix. `CALCulate:LIMit:TRACe` now assigns the limit line to a trace (1 to 4).
`CALCulate:MARKer:TRACe` `CALCulate:DELTamarker:TRACe`		The parameters `NOISe`, `GAIN`, `NMEM1-3` and `GMEM1-3` have been replaced by `1 | 2 | 3 | 4` because no distinction is made between memory and live trace.
`CONFigure:ARRay:MEMory`	`TRACe:COPY`	No more distinction between memory and live traces.
`CONFigure:SINGle`	`CONFigure:FREQuency:SINGle`	
`DISPlay:ARRay:MEMory:STATe` `DISPlay:CURRent:DATA:STATe`	`DISPlay:WINDow:TRACe:STATe`	No more distinction between memory and live traces.
`DISPlay:DATA:TRACe`	`LAYout` system	
`DISPlay:FORMat`	---	Functionality not supported any more.
`DISPlay:WINDow:TABLe`	`LAYout:WINDow:REPLace` / `LAYout:REPLace:WINDow`	
`FETCh:` command system	`TRACE:DATA`	
`SENSe:SWEep:POINts`	`SENSe:FREQuency:POINts`	
`SENSe:FREQuency:CW:FIXed`	`SENSe:FREQuency:SINGle`	
`SENSe:FREQuency:LIST:DATA`	`SENSe:FREQuency:TABLe:DATA`	Frequency table only requires RF frequencies on R&S ZNL.

Legacy command	Replaced by	Comment
SENSe:CONFigure:MODE:SYSTem:LOSCillator	SENSe:CONFigure:MODE:SYSTem:LO	
SENSe:CONFigure:MODE:SYSTem:LOSCillator:FREQuency	SENSe:CONFigure:MODE:SYSTem:LO:FREQuency	

7.21 Programming example: measuring a noise figure

```
// Preset and start option K30
*RST
INSTrument:SELect NOISE

// Set frequencies
SENSe:FREQuency:STARt   100000
SENSe:FREQuency:STOP    3000000000
SENSe:FREQuency:POINts  201

// ENR settings
SENSe:CORRection:ENR:MODE TABLe
// Set the ENR values of your noise source here
SENSe:CORRection:ENR:MEASurement:TABLe:DATA 100e3, 15.77, 10e6, 15.77, 100e6, 15.35,
1e9, 15.12, 2e9, 14.70, 3e9, 14.57

// Set meas time
SENSe:SWEep:TIME  300ms

// Configure and start calibration
SENSe:CONFigure:CORRection
INITiate:IMMediate
*OPC
SENSe:CORRection:STATe ON

// Configure and start measurement
// --> don't forget to add the DUT to the signal path here
// Configure a frequency list measurement with the settings above in single sweep
SENSe:CONFigure:LIST:SINGLe
INITiate:IMMediate
*OPC
```

Annex

A Reference: frequency table file format

Frequency tables can be exported to a file in xml format for further evaluation in other applications. Transducer factors stored in the specified xml format can also be imported to the R&S ZNL for other measurements (see "Import / Export" on page 49). This reference describes in detail the format of the export/import files for frequency tables.

```
<?xml version="1.0" encoding="UTF-8"?>
<TableAttributes>
    <Header comment=""/>
    <Data freq="" value=""/>
    ...
</TableAttributes>
```

Example: Import file for a frequency table

```
<?xml version="1.0" encoding="UTF-8"?>
<TableAttributes>
    <Header comment="Frequency values for NC364B (example)"/>
    <Data freq="10000000" value="13.14"/>
    <Data freq="100000000" value="13.21"/>
    <Data freq="1000000000" value="13.22"/>
    <Data freq="2000000000" value="13.17"/>
    <Data freq="3000000000" value="13.26"/>
    <Data freq="4000000000" value="13.38"/>
    <Data freq="5000000000" value="13.53"/>
    <Data freq="6000000000" value="13.63"/>
    <Data freq="7000000000" value="13.81"/>
</TableAttributes>
```

List of commands (noise figure measurements)

[SENSe:]BANDwidth:LIST:DATA 109
[SENSe:]BANDwidth:RESolution:AUTO 129
[SENSe:]BANDwidth[:RESolution] 128
[SENSe:]BWIDth:RESolution:AUTO 129
[SENSe:]BWIDth[:RESolution] 128
[SENSe:]CONFigure:CONTrol 146
[SENSe:]CONFigure:CORRection 129
[SENSe:]CONFigure:FREQuency:CONTinuous 107
[SENSe:]CONFigure:FREQuency:SINGle 108
[SENSe:]CONFigure:LIST:CONTinuous 108
[SENSe:]CONFigure:LIST:SINGle 108
[SENSe:]CONFigure:MEASurement 146
[SENSe:]CONFigure:MODE:DUT 113
[SENSe:]CONFigure:MODE:SYSTem:LO 112
[SENSe:]CONFigure:MODE:SYSTem:LO:FREQuency 112
[SENSe:]CORRection:ENR:CALibration:MODE 115
[SENSe:]CORRection:ENR:CALibration:SNS:SRNumber 121
[SENSe:]CORRection:ENR:CALibration:SPOT 115
[SENSe:]CORRection:ENR:CALibration:SPOT:COLD 114
[SENSe:]CORRection:ENR:CALibration:SPOT:HOT 114
[SENSe:]CORRection:ENR:CALibration:TABLe:SELect 115
[SENSe:]CORRection:ENR:CALibration:TYPE 116
[SENSe:]CORRection:ENR:COMMon 116
[SENSe:]CORRection:ENR[:MEASurement]:MODE 119
[SENSe:]CORRection:ENR[:MEASurement]:SNS:SRNumber 121
[SENSe:]CORRection:ENR[:MEASurement]:SPOT 119
[SENSe:]CORRection:ENR[:MEASurement]:SPOT:COLD 120
[SENSe:]CORRection:ENR[:MEASurement]:SPOT:HOT 120
[SENSe:]CORRection:ENR[:MEASurement]:TABLe:DELete 117
[SENSe:]CORRection:ENR[:MEASurement]:TABLe:LIST? 117
[SENSe:]CORRection:ENR[:MEASurement]:TABLe:SELect 118
[SENSe:]CORRection:ENR[:MEASurement]:TABLe:TEMPerature:DELete 118
[SENSe:]CORRection:ENR[:MEASurement]:TABLe:TEMPerature:LIST? 118
[SENSe:]CORRection:ENR[:MEASurement]:TABLe:TEMPerature[:DATA] 118
[SENSe:]CORRection:ENR[:MEASurement]:TABLe[:DATA] 117
[SENSe:]CORRection:ENR[:MEASurement]:TYPE 119
[SENSe:]CORRection:IREJection 113
[SENSe:]CORRection:LOSS:CALibration:MODE 122
[SENSe:]CORRection:LOSS:CALibration:SPOT 122
[SENSe:]CORRection:LOSS:CALibration:TABLe:DELete 122
[SENSe:]CORRection:LOSS:CALibration:TABLe:LIST? 123
[SENSe:]CORRection:LOSS:CALibration:TABLe:SELect 123
[SENSe:]CORRection:LOSS:CALibration:TABLe[:DATA] 123
[SENSe:]CORRection:LOSS:CALibration:TEMPerature 124
[SENSe:]CORRection:LOSS:INPut:MODE 124

[SENSe:]CORRection:LOSS:INPut:SPOT....124
[SENSe:]CORRection:LOSS:INPut:TABLe:DELete....125
[SENSe:]CORRection:LOSS:INPut:TABLe:LIST?....125
[SENSe:]CORRection:LOSS:INPut:TABLe:SELect....125
[SENSe:]CORRection:LOSS:INPut:TABLe[:DATA]....125
[SENSe:]CORRection:LOSS:INPut:TEMPerature....126
[SENSe:]CORRection:LOSS:OUTPut:MODE....126
[SENSe:]CORRection:LOSS:OUTPut:SPOT....126
[SENSe:]CORRection:LOSS:OUTPut:TABLe:DELete....127
[SENSe:]CORRection:LOSS:OUTPut:TABLe:LIST?....127
[SENSe:]CORRection:LOSS:OUTPut:TABLe:SELect....127
[SENSe:]CORRection:LOSS:OUTPut:TABLe[:DATA]....127
[SENSe:]CORRection:LOSS:OUTPut:TEMPerature....128
[SENSe:]CORRection:RECall....130
[SENSe:]CORRection:SAVE....130
[SENSe:]CORRection:TEMPerature....121
[SENSe:]CORRection[:STATe]....130
[SENSe:]FREQuency:CENTer....108
[SENSe:]FREQuency:LIST:DATA....109
[SENSe:]FREQuency:POINts....110
[SENSe:]FREQuency:SINGle....110
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